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COGON AND RICE STRAW AS RAW MATERIAL FOR PAPER MANUFACTURE

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INTRODUCTION

It is generally believed that the Philippine Islands contain an abundant supply of raw materials for the manufacture of paper. Indeed, the public forests contain a vast amount of standing timber. Wide areas of public and private lands are overgrown with cogon, talahib, and bamboo of various species. However, an adequate supply of fibrous material is only one of the several items required in the production of the finished paper. Fuel, caustic soda, and bleaching, sizing, and coloring materials have to be imported. The fibrous material must not only be available in large quantities and at low cost, but it must also yield a pulp suitable in quality and amount with the least expenditure of chemicals and energy.

The Philippine public forests contain several species of wood that previous experiments in this laboratory [1] showed to be suitable for the production of the mechanical pulp that is largely used in the manufacture of newsprint. The desirable species are widely scattered in the forest, and there is no known area of sufficient extent where these species predominate. There is, of course, the possibility of planting sufficiently large areas with the species that experiments have shown to be suitable for conversion into mechanical pulp. This would take a long time, and

[1] Philip. Journ. Sci. § A 2 (1907) 81–89.

until it is done, there appears to be no prospect for the establishment of a paper factory.

The desirability of establishing a paper factory in the Philippines is unquestionable. So far, however, no serious attempt has been made to manufacture paper in the Islands. This may be due to the uncertainty attached to every new business venture or to lack of capital. For economical production the capacity of the paper factory should be at least 10 tons of paper per day, which would require an investment of about three-fourths of a million pesos. The Philippine Government has tried to encourage the establishment of new industries by guaranteeing a small profit on the investment. However, no one has taken advantage of the Government's help because the returns on capital invested are much greater in established business enterprises. It seems, therefore, that a more substantial inducement should be offered to capital desiring to invest in new Philippine industries.

COGON GRASS

Cogon grass grows wild in many parts of the Islands on public as well as on private lands. It is a hardy plant and very difficult to eradicate. The provinces that have good means of communication with Manila and contain large areas of cogon are Rizal, Pampanga, Tarlac, Pangasinan, and Nueva Ecija. With the increase in population the area of cogon will gradually diminish, because more land will be taken up for agricultural purposes. However, the cogon area is so large that the grass will be available for many years to come. The cogon fields are usually burned during the dry season, either purposely or accidentally, thus cleaning the fields and promoting new growth. Domestic animals do not eat the mature cogon, but relish the young cogon.

The period of growth of cogon begins with the first rains in May, and during the rainy months of June, July, August, and September the growth is very rapid. Towards the close of the rainy season in October and November the growth is slower. With the advent of the dry season in December or January, the growth is practically arrested and the grass gradually dries up as the dry season advances.

An investigation was undertaken to estimate the yield of cogon per unit area and the changes in the cellulose content during the period of growth. A rolling field covered with cogon

in Alabang, Rizal Province, Luzon, was selected for the experiment. The land is considered by the farmers in the neighborhood to be of medium fertility. Plots measuring 1 by 10 meters were marked out, and the grass was cut at various periods during its growth. The cut grass was immediately weighed in the field and then taken to the laboratory for analysis. The method of analysis used was that recommended by Cross and Bevan. The yield of cogon is given in Table 1 and the chemical analyses in Table 2.

TABLE 1.—*Yield of cogon grass on measured plots at Alabang, Luzon.*

Lot No.	Date cut.	Yield of lot.	Moisture loss on air drying.	Total moisture content.	Yield of cogon grass per hectare.		Average height of cogon.
					Freshly cut.	Oven dried 100°–105° C.	
		kg.	*Per cent.*	*Per cent.*	*Metric tons.*	*Metric tons.*	*cm.*
1	Aug. 24, 1927	18.5	57.0	€0.7	18.5	7.3	116
2	Sept. 28, 1927	22.4	55.2	58.6	22.4	9.3	136
3	Oct. 26, 1927	22.0	48.5	51.9	22.0	10.6	143
4	Nov. 23, 1927	26.5	46.7	51.2	26.5	12.9	160
5	Dec. 23, 1927	25.0	42.5	47.2	25.0	13.2	165
6	Jan. 6, 1928	23.5	31.4	36.5	23.5	14.9	163

TABLE 2.—*Analyses of air-dried cogon grass from plots at Alabang, Rizal.*

Lot No.	Date cut.	Moisture.	Aqueous extract.	Fats and waxes.	Ash.	Total cellulose.	Pectose bodies by difference.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	Aug. 24, 1927	8.64	6.20	1.92	4.49	44.84	33.91
2	Sept. 28, 1927	7.53	7.23	1.42	4.75	46.55	32.52
3	Oct. 26, 1927	6.65	8.19	1.27	5.65	46.99	31.25
4	Nov. 23, 1927	8.46	7.37	1.13	6.72	45.18	31.14
5	Dec. 23, 1927	8.28	6.75	1.13	6.72	45.35	31.77
6	Jan. 23, 1928	7.14	6.15	1.22	6.20	46.74	32.55

It will be seen from Table 1 that the yield of fresh cogon increases from 18.5 metric tons per hectare in August to 26.5 metric tons toward the close of the rainy season in November. From December the cogon gradually assumes a dryer appearance because of a decrease in the water content. However, the yield of dry cogon per hectare increases with age. The analyses recorded in Table 2 show that air-dried cogon has approximately 8 per cent of moisture. Computed on the dry basis the ash has a

TABLE 3.—*Digestion and bleaching test of cogon and rice straw.*

Material used.	Caustic soda (100 per cent) per 100 parts of sun-dried material.	Yield of pulp oven-dried per 100 parts of oven-dried material.	Weight of beaten pulp (oven-dried).	Strength of bleaching solution. Per cent available chlorine.	Total available chlorine in solution.	Excess of chlorine.	Bleaching powder (30 per cent available chlorine) consumed per 100 parts of oven-dried pulp.	Loss of pulp in bleaching per 100 parts of oven-dried pulp.	Hours of bleaching.
			g.		*g.*	*g.*	*g.*		
Cogon	20	31	8.916	0.50	0.4686	0.00142	17	11	25
			8.916	0.94	0.9372	0.33758	22	9	1
Do	15	35	9.785	0.50	0.6600	None	22	12	25
			9.785	0.94	0.9000	0.00920	30	7	2
Do	12	36.2	8.914	0.50	0.9372	Traces	35	9	25
			8.914	0.94	1.8744	0.49640	51	14	2
Do	10	37.4	9.815	0.44	1.2496	Traces	42	17	23
			9.815	0.94	1.8744	0.18080	57	18	2
Rice straw	4	46.9	[a] 11.606	0.49	0.6090	0.009	17	9	25
			11.606	0.92	1.2180	0.2059	29	9	2
Do	8	45.9	9.712	0.50	0.5991	0.0953	17	7	1.5
			9.712	1.00	1.1982	0.1411	36	11	1.5

[a] Bleached pulp is brownish.

marked tendency to increase with maturity. On the other hand, the cellulose content does not seem to be greatly affected by the age of the grass.

Cogon is preferably cut during the dry season; at that time the rice farmers have completed their field work and are available for harvesting the grass. Then, too, if cogon is cut during the rainy season it is liable to rot on the field. Transportation is generally difficult during the rainy season.

Careful inquiry among farmers as to the probable cost of cogon indicates that air-dried cogon in bulk or in bales can be delivered in Manila at from 20 to 25 pesos per metric ton.

Digestions of cogon with varying amounts of caustic soda to determine the yield of pulp and the quantity of bleaching powder required to bleach to standard color were carried out. The process is as follows:

Two hundred fifty grams of cogon cut into pieces 7 to 10 centimeters in length were taken for each digestion. The weighed sodium hydroxide was dissolved in 1,650 cubic centimeters of water, which was found sufficient to cover the grass. The digestion was carried out at from 160 to 165° C. for a period of three hours. When the digester had sufficiently cooled, the contents were placed on a 50-mesh screen and thoroughly washed until the wash water was no longer colored. The pulp was then beaten in a porcelain or iron mortar, washed, and dried in the oven.

For bleaching the pulp about 8 to 10 grams of oven-dried pulp were soaked in a definite quantity of water and repulped in a beaker. The bleaching-powder solution was then added. The excess of chlorine was determined by titration with sodium thiosulphate. The pulp, bleached to standard color, was washed thoroughly and dried in the oven to constant weight. The results obtained are given in Table 3.

The tensile strength of handmade cogon paper, sized with starch and tested in strips 2 inches wide and 2 inches between clamps in a Schopper paper-testing machine, is given in Table 4.

The possibility of using cogon for the manufacture of cardboard was also determined. For this purpose the grass was digested with lower percentages of caustic soda and also with lime. The digestion was carried on at 160 to 165° for three hours using 500 grams of cogon and 3,300 cubic centimeters of the digesting solution. The results show that 4 per cent of caustic soda (100 per cent pure) was the minimum amount that

could be used to produce a pulp suitable for cardboard production, and that the yield amounts to 51.5 parts of oven-dried pulp per 100 weight of oven-dried cogon. Digested with 12.7 per cent quick lime, the resulting pulp was incompletely digested and difficult to beat. To produce a pulp similar to that produced by 4 per cent caustic soda requires 25 per cent of lime. The market price of caustic soda is 150 pesos per ton, and of lime 40 pesos per ton. At these prices it will be seen that it is much cheaper to use caustic soda than lime. Table 5 shows the relative ease of reducing cogon and rice straw into pulp for the manufacture of cardboard when digested with caustic soda and with lime.

TABLE 4.—*Tensile strength of handmade cogon paper.*

[Two-inch strips and 2 inches between clumps.]

No. of test.	Thickness.	Tensile strength.
	mm.	*kg.*
1	0.100	7.8
2	0.091	9.0
3	0.080	6.4
4	0.080	7.1
5	0.090	9.1
6	0.095	8.3
7	0.080	7.6
8	0.085	6.6
9	0.088	7.7
10	0.085	6.8
Average	0.087	7.6

TABLE 5.—*Digestion of cogon and rice straw with soda and lime.*

Material.	Caustic soda (100 per cent) used per 100 parts of air-dried material.	Oven-dried pulp obtained per 100 parts of oven-dried material.	Lime (100 per cent) per 100 parts of air-dried material.	Oven-dried pulp obtained per 100 parts of oven-dried material.
Cogon	4	51.5	12.7	64.0
Rice straw	2	55.4	12.7	56.7
Do	4	46.9	6.1	58.4

RICE STRAW

Rice is grown throughout the Philippine Islands and is the principal food of the people. The provinces of central Luzon in which the rice plant is extensively cultivated, are considered

the granary of the Philippines. The principal rice-producing provinces are Bulacan, Pampanga, Tarlac, Pangasinan, and Nueva Ecija. These provinces are crossed by railroads leading to Manila. Motor transportation between Manila and these provinces is highly developed through a system of good public roads. The navigable Pampanga River drains Bulacan, Pampanga, and Nueva Ecija Provinces.

It is customary in these provinces to harvest the rice plant including the straw. The harvested plant is exposed to the sun in order to dry the grain. After drying, the grain is separated from the straw either by hand, by animal power, or by means of threshing machines. The rice straw is usually left on the ground to rot and serves as a fertilizer to increase the humous content of the soil. A part of the straw is sometimes used for feeding work animals, but the greater part is wasted. However, in the districts near Manila, the rice straw is sent to Manila in bulk, where it finds a ready sale as bedding for work animals and to some extent as feed for carabaos.

The rice grown in central Luzon is usually shipped to Manila by rail, although motor-truck transportation is becoming more important particularly in the nearby provinces. At present, rice straw is usually shipped to Manila in bulk by means of river boats or is loaded on bamboo rafts and floated down the river. Rice straw is sold in Manila in bales at 2.5 centavos per kilogram. A dealer in rice straw assured one of us that he finds no difficulty in purchasing as much as 3,000 to 4,000 tons of rice straw in one season from Bulacan Province alone at from 1.5 to 2 centavos per kilogram delivered in his warehouse in Tondo alongside the river. A lower price is paid during the harvest time and for two or three months thereafter. Later in the season a higher price is demanded. The fact is that the supply of rice straw is very much greater than the demand.

In Table 6 are given the area planted to rice, the yield of grain, and the estimated yield of straw. [2]

Possibly one-half to two-thirds of the amount of straw produced by the five provinces named in Table 6 is not easily available for commercial use, due either to the great distances from the shipping point or to the difficult means of transportation. Rice grown within a reasonable distance of rivers and canals, highways and railroad lines is available for pulp and paper manufacture.

[2] From the annual report of the Bureau of Agriculture for 1925.

TABLE 6.—*The area planted to rice, the yield of grain, and the estimated yield of straw in five provinces of central Luzon.*

Province.	Area planted.	Yield of grain.	Estimated rice straw produced.	Tons of straw per hectare.
	Hectares.	*Metric tons.*	*Metric tons.*	*Tons.*
Bulacan	58,900	74,200	123,000	2.1
Pampanga	71,110	79,400	138,000	1.9
Nueva Ecija	177,710	314,000	515,000	2.9
Tarlac	80,120	81,200	136,000	1.7
Pangasinan	195,890	309,000	509,000	2.6
Total	583,730	857,800	1,421,000	[a] 2.24

[a] Average per hectare.

A portable bailing machine could go with the threshing machine to bale the straw produced by the latter. The total expense in bailing rice straw does not exceed 3 centavos per bale of 40 kilograms. The farmer could thus get an additional income from the sale of the straw.

Assuming that only one-tenth of the rice straw produced is available for paper manufacture, Bulacan Province alone is able to supply a 10-ton paper mill. The staple food of the inhabitants being rice, it is reasonable to expect that as the population increases, more rice will be planted and consequently more straw will be available for paper manufacture.

Rice straw is used in Japan and other rice-producing countries as a raw material for paper and cardboard manufacture. The demand in Japan is limited only by the supply.

The analysis of a sample of rice straw from Bulacan Province is given in Table 7.

TABLE 7.—*Rice straw from Bulacan Province.*

	Per cent.
Moisture	9.84
Ash	15.23
Fats and waxes	1.86
Cellulose	37.84
Aqueous extract	13.66
Pectose bodies	21.57
Total	100.00

The most striking difference between the analysis of rice straw and of cogon grass is the quantity of ash and cellulose. Rice straw has two and one-half times as much ash as cogon, whereas

the cellulose content based on the dried materials is only about 42 per cent for rice straw against 50 per cent for cogon.

Digestion experiments were made with rice straw using the same procedure as that used for cogon, with the exception that instead of 1,650 cubic centimeters of solution the volume used was 2,000 cubic centimeters. The results obtained are given in Table 3.

The strength of handmade rice-straw paper sized with starch and tested in strips 2 inches wide and 2 inches between clamps is given in Table 8.

TABLE 8.—*Tensile strength of rice-straw paper.*

[Two-inch strips and 2 inches between clumps.]

No.	Thickness.	Tensile strength.
	mm.	*kg.*
1	0.089	8.1
2	0.081	5.7
3	0.088	7.2
4	0.108	7.7
5	0.105	9.3
6	0.091	5.9
7	0.077	6.3
8	0.077	6.0
9	0.090	6.1
10	0.091	5.9
Average	0.090	6.8

RICE STRAW FOR CARDBOARD MANUFACTURE

In Table 5 it is shown that rice straw digested with 2 per cent caustic soda produces a pulp suitable for cardboard and easier to beat than cogon pulp obtained with 4 per cent caustic soda. Using 12.7 per cent lime the resulting rice-straw pulp is of the same quality as that produced by using 2 per cent caustic soda. Lower quantities of lime (6.1 per cent) may be used, but the resulting pulp is rather difficult to beat.

CONCLUSIONS

1. Cogon grass and rice straw are available in commercial quantities for the manufacture of paper. Cogon has to be especially cut and dried for this purpose. As the years go by the easily accessible land will be devoted to agriculture with the result that the available cogon fields will be found farther and

farther away from the means of transportation. Cogon fields of medium fertility may be expected to yield about 12 to 16 tons of air-dried grass per hectare.

2. Rice straw, on the other hand, does not have to be cut as it is a waste by-product in threshing the rice plant. The central Luzon rice provinces; namely, Bulacan, Pampanga, Nueva Ecija, Tarlac, and Pangasinan, are estimated to produce 1,421,000 tons of straw averaging about 2.4 tons of rice straw per hectare. Most of the straw produced at present is wasted. Bulacan Province alone is able to supply a 10-ton paper mill with rice straw.

3. Rice straw requires for digestion about one-third as much caustic soda as cogon and is easier to bleach. In the Philippines where chemicals are expensive this is considered a great advantage.

4. Cogon has 50 per cent cellulose and rice straw 42 per cent based on the dry material. Due, however, to the fact that rice straw requires a milder treatment than cogon the yield of pulp from rice straw is about 15 per cent greater than the yield from cogon.

5. Paper made from cogon is stronger than that made from rice straw.

THE FERN GENUS PLAGIOGYRIA

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FIFTEEN PLATES

Genus PLAGIOGYRIA Mettenius

The original generic diagnosis [1] reads as follows:

Sori partem nervorum superiorem, paullulum ac sensim incrassatam, occupantes, distincti vel denique parenchyma nervis interjectam occupantes et confluentes, exindusiati, margine revoluto attenuato obtecti, margine denique explanato denudati. Sporangia pedicellata, helicogyrata, annulo completo obliquo instructa, rima transversali inter cellulas stomii dehiscentia. Sporae tetraëdrico-globosae vel trilobae.

Foliorum petiolus trunco continuus ac basi incrassata persistens, lamina profunde pinnatipartita vel pinnatisecta, difformis; sterilium segmenta serrata, nervis Sub-Taeniopteridis vel Eupteridis dentes intrantibus, liberis; fertilium segmenta angustiora, margine attenuato integra vel lacera, nervis sensim ac paullulum incrassatis, marginem attenuatum non intrantibus, liberis vel arcu intramarginali confluentibus.

A genus of cyatheoid ferns, terrestrial, characterized by short (not arborescent) erect or suberect caudices; the bases of the stipes enlarged, flat on the inner face, and with a strong median ridge on the outer face of each, dividing this face into two surfaces each of which, in most species, bears a row of excrescences construed as aërophores; the stipe containing a single vascular bundle, which expands or divides in the enlarged base; fronds of moderate size, simply pinnate or deeply pinnatifid, dimorphous; veins free, except as the tips of soriferous veinlets may unite; sori submarginal, borne on the swollen forks of once-forked veinlets but becoming confluent, protected while immature by the scarious reflexed margin of the pinna; sporangium with an oblique annulus forming a complete ring.

Plagiogyria is perhaps the most natural—that is, isolated and clearly definable—of all the genera included in recent years in Polypodiaceæ. As usually happens when the nature of such a

[1] Ueber einige Farngattungen. II. Plagiogyria, Abhandl. Senkenberg. naturf. Gesells. 2 (1858) 275.

group is not recognized (compare *Davallodes, Taenitis, Leptochilus, Christiopteris*), different authors have placed these ferns in a variety of unrelated groups. Mettenius and Kuhn included them in Cyatheaceæ. Hooker could see no sufficient ground for generic separation from *Lomaria,* in which the first species were described. Diels and Christensen placed them in the Pterideæ.

In a rearrangement of the genera, on which a general publication is expected to ensue, I place *Plagiogyria* coördinate with *Cyathea,* both in Polypodiaceæ, but lower on the phylogenetic trunk than *Onoclea, Diacalpe, Dryopteris,* and *Athyrium.* Bower [2] gives it substantially the same position, but raises it to family rank, constituting a new family, Plagiogyriaceæ. On rather important grounds of convenience, I do not follow him in this.

The question of general policy involved here was clear a decade ago, and I may as well quote.[3]

> Independent of *Cyathea* and its relatives, and of the Matoniaceae and their descendants, we have in the Polypodiaceae several clear-cut series of descendants of *Dennstaedtia,* or of ancient ferns now best represented by *Dennstaedtia.* These series cross the old tribal lines of the Polypodiaceae, sometimes with but little regard for them. The old artificial tribes, the Aspidieae, Asplenieae, Davallieae, Pterideae, and Vittarieae and Polypodieae, not to speak of the Acrosticheae as a tribe in the older sense, have, therefore, to be recast or abandoned. As to the family conception, it seems to me clear that *Dryopteris,* and even *Athyrium,* as well as *Peranema, Diacalpe, Monachosorum* and *Acrophorus,* and probably all of the Woodsieae, must fall in one family with *Cyathea;* while the descendants of *Dennstaedtia,* including possibly the Polypodieae [4] and Vittarieae,[4] and certainly all of the real Davallieae [5] and Pterideae, form another family; and while the descendants of the Matoniaceae fall in that family [Matoniaceae]—or else we must include in the Polypodiaceae, as completely as we know how to do so, the nearest common ancestry of all of these distinct phylogenetic lines. If we adopt the former alternative, the definition of the resulting families by diagnosis will become a pure impossibility. There seems to me, therefore, no alternative but to include Cyatheae, Matoniaceae and Polypodiaceae in one family, retaining, for the resulting great family, the name by which the overwhelmingly largest part of it is already known.

If, as Bower suggests, we have other genera descended from *Plagiogyria,* or from ferns nearer to it than to any other survivers, the number of ill-defined families that will result from the consistent use of his policy is an open question. Even if,

[2] Ferns 2 (1926) 275.
[3] Sarawak Mus. Journ. 2 (1917) 292, 293.
[4] I now regard these groups, properly construed, as matoniid.
[5] I am now satisfied that *Davallia* itself is not dennstaedtiid.

as is my present belief, *Plagiogyria* is without descendents or "nephews," and is unrelated to any ferns with interrupted annulus except through other ferns with oblique annulus, still I am indisposed to give it family rank; for, although easy enough to recognize and to define, such a family would be far less isolated than any group now recognized by most botanists as a family of Filices—with the sole exception, probably, of Parkeriaceæ, which we may be treating as a family because of what we do not know about *Ceratopteris* fully as much as because of what we do know.

While *Plagiogyria* as a genus dates back only to 1859, and only five species were then known, the distinctness of the group, as shown by one or another character, was recognized earlier. Kunze [6] invented the name for the group, but left it as a subgenus of *Lomaria*. Presl [7] suggested a genus to be recognized by the nature of the vascular bundle in the stipe, and Wallich [8] had already described the enlarged stipe bases.

The anatomical peculiarities of *Plagiogyria* have been studied so well by Mettenius, and more recently by Bower,[9] that I have been content, in most instances, with verifying their findings.

Mettenius, as to *P. semicordata*, and after him Diels, describes the vascular bundle of the stipe as divided into three while it traverses the enlarged base. Bower agrees as to the species named; but in *P. pycnophylla* he finds that, instead of dividing, it becomes very wide and thin, with the middle part displaced squarely outward. This is what happens in the most or all of the Oriental species.

Mettenius construed the aërophores, or pneumatophores, as correlated with the development of hard, impervious, mechanical tissues, providing for the aëration of the living parenchyma in spite of the hard shells which inclose the latter. Bower believes that the aërophores function chiefly while the fronds are still very young, providing for their aëration through an external protective layer of gummy or gelatinous material. Both may be right, but I find more evidence to support Mettenius. The aërophores vary in development with that of the hard and impervious tissues that are construed as making them necessary. *Plagiogyria christii* is less hard and woody than are most Orien-

[6] Bot. Zeit. 7 (1850) 867.
[7] Epim. Bot. (1849) 156.
[8] Quoted by Hooker, Spec. Fil. 3: 21.
[9] Ann. Bot. 24 (1910) 423; Ferns 2 (1926) 275.

tal species, and the aërophores are so feebly developed that they were missed, although looked for, when the species was described. *Plagiogyria petelotii* has very slender bases, with only one or two evident aërophores on each side. *Plagiogyria tuberculata* has the hardest sclerenchyma shells known in the genus, and may have a full dozen distinct excrescences on each side, in two rows or somewhat irregularly placed. It likewise bears them, where there is no other suggestion of pinnæ, on the upper part of the stipe.

When these excrescences are produced on the rachis, they are immediately adjacent to the insertion of the pinnæ. If alternating with the pinnæ of very young fronds, as described and figured by Bower (p. 277), they might possibly still be adjacent to the attachment of the pinnæ after the frond is expanded; but I have not been able to see, in very young fronds of *P. pycnophylla* or of any other species, either that they are so placed or that they precede the other structures in development to the extent that Bower depicts.

Mettenius describes and figures a marginal veinlet connecting the tips of the fertile veinlets of *P. scandens*, but of no other species. His *P. scandens* is understood to be *P. pycnophylla*. No such marginal strand could be found in Bower's material of this species or in mine.

It does not seem to have occurred to Mettenius or to Bower to give any biologic explanation of the dimorphous fronds or the acrostichoid fructification of *Plagiogyria*, perhaps because so many other ferns have also these features. These and the scarious margin of the fertile frond are paralleled in a number of distinct phylogenetic lines, but are none the less interesting for that reason, in the biologic understanding of *Plagiogyria*.

Dimorphism and acrostichoid fructification do not always go together. *Elaphoglossum* and *Acrostichum* (as to the pinnæ) are acrostichoid without much contraction of the fertile frond, and the contraction is not extreme in *Egenolfia*. Some species of *Cyathea*, and more of *Phymatodes*, have moderately dimorphous fronds and definite sori; and *Tectaridium* has extremely dimorphous fronds but retains its indusia. Still, the instances in which loss of area and indefinite fructification are associated far outnumber those in which one of these features is found without the other; *Osmunda* (*cinnamomea*), *Stenosemia*, *Polybotrya*, *Psomiocarpa*, *Hemigramma*, *Stenochlaena*, *Christiopteris*, *Cheiropleuria*, *Platycerium*, *Leptochilus*, *Loma-*

gramma, most species of *Campium,* and *Merinthosorus* (as to the pinnæ) should be a long enough list to make this clear. For additional similar examples, it may be noted that in *Aglaomorpha, Photinopteris* and *Thayeria* (as to the pinnæ), in *Drymoglossum,* and notably in certain species of *Loxogramme,* contraction of lamina is associated with expansion of the sori, without their yet becoming fully acrostichoid. The joint evolution of a pair of characters in a score of distinct evolutionary lines is proof enough of their causal connection.

Plagiogyria belongs in this list. In most species the fertile pinnæ are just wide enough to bear a good belt of sporangia on each side of the costa; and in the American species, though the contraction is usually less extreme, it extends to the essential loss of sterile lamina by these fronds. Mettenius noted the comparative restriction of the sporangia to the veinlets of *P. glauca,* and their spread to the "parenchyma" of the other species he knew. In this respect, *P. pycnophylla* is like *P. glauca,* and *P. euphlebia* is somewhat so. In all species the sporangia are most congested on the veinlets; and in no species, even those just named, are they so confined to the veinlets as to prevent their crowding all of the available surface as they mature.

If the significance of the acrostichoid evolution (for this feature is never primitive; in the most of the groups named, the descent from known ancestors with definite sori and uniform fronds is already clear) were in the production of more sporangia, the contraction of the lamina would seem to defeat or curtail this accomplishment. The fact is that there are several elements in this evolution.[10] The one advantage always attained, and attained in association with the contraction of the frond, is not in the production but in the dissemination of the spores. My belief is that the available material is the usual limiting factor on the production of spores, and that no advantage is to be gained by ferns in general by an increase in the fruiting area. There is of course a premium on the protection of sporangia and spores; ferns care for this by a considerable variety of protective "devices." A problem at least equally general seems to be dissemination; for their most numerous and conspicuous peculiarities are to be interpreted as special devices to accomplish this.

The back of the normal frond, where the sporangia are borne by the ancestors of every genus listed in this connection, unless

[10] See my paper on comparative ecology of the Polypodiaceæ, Philip. Journ. Sci. § C 2 (1907) 1–74, 4 pls.

it be *Osmunda,* seems to be a satisfactory place for their production; but not nearly so good for the scattering of the spores. Aside from the fact that the body of the frond is in the way of their free discharge into the air, its back is a damp place—must be a damp place for the plant's vegetable welfare, but the spores must be discharged into dry air, if, in general, they are to have any good chance of wide dispersal. This is so absolutely necessary that the mechanism of the annulus has been evolved to discharge them when the air is dry, and only then. The contraction of the fertile frond gets rid of the area of leaf that obstructs dispersal and guards a supply of humid air beneath itself. Also, not having to guard against desiccation as the vegetative frond must do, the specialized fertile frond can be located specifically where the chance of being dry is greatest. Thus, the fertile pinnæ of practically every genus and species, bearing dimorphous pinnæ on the same frond, are borne at the apex. Thus, the fertile part of the simple frond of *Hymenolepis* is a very contracted apical segment. Thus, in *Plagiogyria,* as is the general rule when the whole frond is differentiated, the fertile frond has a much longer stipe than does the sterile. The sterile fronds are exposed to light, and to the danger of the wind, just as far as the selective ancestral experience has proven to be safe. The fertile fronds are carried beyond this point, exposing the mature sporangia to conditions of dryness which may not be chanced by the vegetative frond. As the vegetative leaf could not be expected to endure and function, if exposed as are the fertile fronds, the vegetative structures and area of the latter are done away with. With the loss in area the acrostichoid stand of the sori is too obviously correlated to require further discussion.

The scarious margin is sometimes called a false indusium. Similar structures are found in many of the genera regarded as relatives of *Pteris,* in many species of *Vittaria,* in *Hymenolepis platyrhynchos,* and in *Oreogrammitis.* They may be expected to perform the function of indusia better than indusia can. This function is protection of the sporangia and spores while protection is needed. While the sporangia are immature, this cover is folded tightly over them. When they, or a part of them, are mature, and the spores are ready to be scattered, the cover rises—or rather sinks—away from them, and swings outward, and finally upward, giving the bed or line of sporangia free

exposure to the air. Because these false indusia are more massive and complicated in structure than are real indusia, their movement can be, and is, hygroscopic, and reversible. Exposed to desiccation, they so move as to expose the sporangia to the same influence. Wet again, they perform the reverse movement, folding back more or less tightly over the fruiting surface. Even in old herbarium specimens this motility is not wholly lost. If a frond with the sporangia exposed be soaked for study, the sporangia may then be found securely covered.

The structural peculiarities of *Plagiogyria* would pass as evidence of considerable geologic age, but its geographic distribution is that of a comparatively new genus. The appreciable number of local species, and the focusing of these, in China and Borneo, are indications of recent evolutionary activity; that is, *Plagiogyria* is not another *Sequoia* or *Matonia*. My belief is that it is a fern of approximately Chinese origin, and that its present distribution marks the spread it has been able to make. There are more species in China than anywhere else. Every species of at all wide Oriental distribution is found there, and in whatever direction a line of possible fern migration is followed, the number of species grows less, and the genus presently disappears. The presence of eight species in Borneo offers the only considerable exception to the regularity of this thinning out with distance from China. This is due to two pairs of local species; of these four, three have been collected once each, and the remaining one twice. As a real element of the fern flora, the place of *Plagiogyria* in Borneo is probably not much more prominent than its position with regard to China would make probable. The report of eight species from the Philippines merely expresses the more thorough exploration and study there. Of these eight, one (*P. nana*) is of questionable status; one (*P. christii*) is very close to a Chinese species; and one (*P. falcata*) is very local. Elsewhere in the Orient, between Java and Japan, such a local species, however well marked, is likely to await future detection.

To the west, all of the four most wide-spread species reach to the Himalayas, but none is known in peninsular India. To the south, three of the same four reach Java. Toward the southeast, only a single species is known to reach Celebes, though the typically Malayan fern flora blankets Celebes and New Guinea without a break. Beyond Celebes there is a report of *P. euphle-*

bia in New Guinea; but I mistrust it, because this species is not otherwise known to approach New Guinea, and I have received under this name a New Guinea fern of another genus.

Still farther, *P. euphlebia* is regularly cited from Queensland. It is an eloquent testimonial to the service of Hooker and Baker to pteridology that this error has remained current and unquestioned for fifty years. Ferdinand Müller [11] described a new species, *Lomaria articulata,* with pinnæ articulate to the rachis, so loosely jointed that, as Bailey's "lithogram" shows,[12] the frond falls apart in drying. Because of resemblance in the form of the pinnæ, Müller carefully and, one would have supposed, sufficiently distinguished it from *Lomaria euphlebia,* in his original publication. But this did not deter Baker [13] from combining the two, nor Bailey, Diels, Christensen, nor Hayata from perpetuating Baker's error. I have never seen the fern, but I do not believe that Müller could see paleæ where there were none; and am sure that any fern with *"stipite . . . basin versus . . . squamis brunneo-nigris onusto"* (Müller, loc. cit.) is no *Plagiogyria.* Baker[14] also reported *P. adnata* from Fiji and said it was the same as the Queensland species.

To the northeast, two species are common in Japan. A third, *P. adnata,* is reported, but the several Japanese specimens I have seen with this name represent aonther, and local, species. *Plagiogyria matsumureana* is especially interesting because of its evident near relationship to the group of American species. It presents the evidence that in this genus Japan was the western point of contact between the two continents.

The question of primitiveness of species within the genus is tied up with that of the direction in which the Pacific was crossed. Bower (in his earlier publication) was disposed to regard *P. semicordata* as primitive in the genus. If it is, the Pacific was probably crossed toward the west. My own present view is that *P. pycnophylla* and *P. adnata* are more primitive. The comparative wealth of the Old World, in known species and in their diversity, indicates greater age there. Both of the species just named are widely distributed. Each has been the apparent point of departure for the evolution of a number of

[11] Fragmenta 5 (1866) 187.
[12] Ferns of Queensland, pl. 87.
[13] Synopsis 183.
[14] Journ. Bot. 17 (1879) 295.

daughter species—those of *P. pycnophylla* in the southern part of the area, those of *P. adnata* in the north and northeast. If the genus had reached the Orient substantially in the form of *P. matsumureana,* this, instead of *P. pycnophylla* and *P. adnata,* should have established a range to India and Java. As I construe the evidence, the group of *P. adnata* evolved freely in China, established there a substantial dispersal pressure, and reached Japan in approximately the form of *P. matsumureana.* Thence it jumped the ocean, just once and by a single jump, and established itself with very little modification. From such a fern as this, the American species are presumed to be descended, but there has been in America no evolution of distinct groups of species, such as are evident in the Orient. On certain morphologic grounds, I might have picked *P. euphlebia* as the most primitive species; but I am unable to recognize these as presenting, in this instance, as strong a case as is established on geographic considerations.

The chief service of a treatise of this kind is to facilitate the study of the genus by others. Theoretically, it might be to make such study unnecessary; but the lesson of experience is that whenever a monograph is accepted for any considerable time as final, the result is that its field lags behind others. For the material assistance of other students, I have assembled here the original diagnoses of all species known to be *Plagiogyria,* giving, when necessary, an additional description of each species as I construe it. In a single instance, the original publication being in French after the adoption of international rules prescribing Latin, I have substituted a translation; otherwise, these republications are literal.

While a large part of the material serving for this study is in my own herbarium, I would be wanting in appreciation if I failed to acknowledge the help, in this and in several other studies carried on at the same time, given me by Dean Merrill and the botanical department of the University of California, in placing at my disposal their herbarium and library facilities. After practically completing the study of the Oriental species, I received, by the kindness of Mr. Maxon, the rich material of the United States National Herbarium; my study of the American species is based almost wholly on this collection. To Doctor Christensen, I am indebted for the opportunity of inspecting the type of *Lomaria pectinata* Liebmann.

Distribution of the Oriental species of Plagiogyria.

[The American species of *Plagiogyria* have not been collected and distinguished sufficiently to make their tabulation instructive.]

Plagiogyria.—	Celebes.	Java.	Sumatra.	Borneo.	Philippines.	Himalaya.	China.	Formosa.	Japan.
pycnophylla		×		×	×	×	×		
tuberculata			×	×	×				
glauca	×	×		×	×	×	×	×	
nana					×				
egenolfioides				×					
minuta				×					
rotundipinnata				×					
clemensiae				×					
euphlebia						×	×	×	×
christii					×		×		
grandis							×		
intermedia									×
adnata		×	×	×	×	×	×		
sumatrana			×						
assurgens							×		
stenoptera					×		×	×	
henryi							×		
petelotii							×		
falcata					×				
tenuifolia							×		
dunnii							×		
hayatana							×	×	
argutissima							×		
matsumureana									×
Total	1	3	3	8	8	4	14	4	3

Key to the species of Plagiogyria.

Oriental species; fertile pinnæ mostly narrowly linear.

1. Dwarfs, not glaucous.
   2. Sterile pinnæ narrow at base ..... 10. *P. minuta.*
   2. Sterile pinnæ cordate or auricled ..... 19. *P. egenolfioides.*
1. Not dwarfs, or glaucous beneath.
   2. Small ferns with obtuse pinnæ ..... 8. *P. nana.*
   2. Large ferns with pointed pinnæ ..... 7. *P. glauca.*
1. Not dwarfs nor glaucous, pinnæ mostly free.
   2. Apical leaflet like the others, and free.
      3. Subcoriaceous, brownish green.
         4. Pinnæ acuminate ..... 1. *P. euphlebia.*
         4. Pinnæ finely caudate ..... 3. *P. grandis.*
      3. Thinner and dark green ..... 2. *P. christii.*
   2. Apical segment like pinnæ, but confluent ..... 4. *P. intermedia.*
   2. Apex of frond pinnatifid.
      3. Margin toothed throughout ..... 5. *P. pycnophylla.*
      3. Pinnæ entire except near apex.
         4. Pinnæ about 1.0 cm wide ..... 6. *P. tuberculata.*
         4. Pinnæ about 1.5 cm wide ..... 6. *P. sumatrana.*

1. Not dwarfs nor glaucous, most pinnæ adnate.
  2. Apical leaflet like others.
    3. Apical leaflet longer than others..... 11. *P. rotundipinnata.*
    3. Apical leaflet shorter than medial..... 12. *P. clemensiae.*
  2. Apex of frond pinnatifid.
    3. Lowest pinnæ extremely reduced.
      4. Pinnæ serrate, mostly contiguous at base.
        5. Frond linear-lanceolate..... 17. *P. petelotii.*
        5. Frond broadly lanceolate.
          6. Dwarfed lower pinnæ few..... 15. *P. stenoptera.*
          6. Dwarfed pinnæ about ten..... 16. *P. henryi.*
      4. Pinnæ serrate, connected by a wing..... 14. *P. assurgens.*
      4. Pinnæ biserrate, contiguous..... 22. *P. argutissima.*
    3. Lowest pinnæ not, or moderately, reduced.
      4. Lower pinnæ narrowed at base.
        5. Tubercles on rachis few or none..... 13. *P. adnata.*
        5. Each pinna subtended by a tubercle..... 6. *P. sumatrana.*
      4. Pinnæ not contracted at base.
        5. Veinlets not forked..... 18. *P. falcata.*
        5. Most veinlets forked.
          6. Teeth regular and simple.
            7. Segments lanceolate, acute..... 19. *P. tenuifolia.*
            7. Segments narrower, acuminate.
              8. Segments near together..... 20. *P. hayatana.*
              8. Segments their own width apart..... 21. *P. dunnii.*
          6. Segments irregularly biserrate..... 23. *P. matsumureana.*

American species; fertile pinnæ broadly linear. (For key to the American species see p. 406.)

1. PLAGIOGYRIA EUPHLEBIA (Kunze) Mettenius.

Plagiogyria euphlebia (Kunze) METTENIUS, Plagiogyria (1858) No. 6. (Cited by species number because there are two series of page numbers.)

Lomaria euphlebia KUNZE, Bot. Zeit. 6 (1848) 521.

Fronde oblonga, acuminata, coriacea, subtus pallidiore, pinnata; pinnis remotiusculis, erecto-patentibus, sterilibus lanceolatis, subfalcatis, marginatis, margine reflexo obtuse denticulatis, basi in petiolum brevem attenuatis, in rhachi subdecurrentem, superioribus adnatis, apice attenuato cuspidato-acuminatis, cuspide serrulatis, costatis, costa utrinque, imprimis, subtus elevata, depresso-canaliculata, puberula, venis distinctis, remotis, subtus elevatis, plerisque furcatis; fertilibus breviter petiolatis, linearibus, obtusis, subapiculatis, basi subcordatis, supra impresse fusco-venosis; rhachi stipiteque mediocri, quadrangulo, sulcato glabris, opacis, purpurescentifucis; rhizomate . . . . Japonia.—METTENIUS.

The caudex is stout, suberect, and buried in old stipe bases, as is characteristic of the genus. The stipes of sterile fronds are 15 to 30 centimeters or more long; of fertile fronds, commonly a little longer. The sterile frond is 30 to 60 centimeters long, 20 to 30 centimeters wide, pinnate; the sterile pinnæ usually about

ten on a side, the lowest not appreciably reduced, nor conspicuously deflexed; the medial ones nearly horizontal, narrowly lanceolate, acuminate or caudate and there sharply and rather coarsely serrate, elsewhere obscurely toothed. The pinnæ may all be free, but more commonly one or two of the upmost ones on each side are partly adnate; all are narrowed to the base, and nearly all are rather symmetrically and gradually narrowed and stalked; not subtended by tubercles. From the most of the genus, this and the following species are sharply distinguished by the large terminal leaflet, like the lateral ones, or with a lobe or two at the base; they are equally distinguished by having few, large, stalked pinnæ, not crowded together, and in the comparatively lax venation. The texture is described as coriaceous, but is really too thin in most specimens to be properly so designated. The color is either clear green or brownish green, the two surfaces practically alike. Altogether, the sterile frond has more the aspect of a *Stenochlaena* than that of other species of its own genus.

The accepted range is from Japan and Formosa across China to northern India. To this, van Alderwerelt adds Malacca and New Guinea; but the New Guinea fern I have received under this name is a *Lomaria*. Judging by the frequency of collection, it is common in Japan and China.

The Indian representatives were *Acrostichum triquetrum* of Wallich's Catalogue, and described as *Plagiogyria triquetra* by Mettenius.[15] Indian and Chinese specimens seem to average a little larger than Japanese, with the lowest pinnæ a little more remote; but the differences are both trivial and inconstant.

2. PLAGIOGYRIA CHRISTII Copeland.

Plagiogyria christii COPELAND, Philip. Journ. Sci. Suppl. 1 (2906) 153.

Caudice erecto, breve; stipitibus confertis, 20–30 cm. altis, glabris, castaneis, nitidis, basibus incrassatis, tuberculis carentibus; frondibus 40–60 cm. altis, pinnatis; frondis sterilis pinnis utrique ca. 13, fere horizontalibus, inferioribus brevissime pedicellatis superioribus adnatis, ca. 13 cm. longis, 15–20 cm. latis, acuminatis, serrulatis, glabris, herbaceis venis simplicibus vel furcatis; frondis fertilis pinnis utrinque 12–16, remotis, pedicellatis ver supremis adnatis, linearibus, 10 cm. longis, 2–3 mm. latis; sporis ad apices venularum confertis, primo margine membranacea inflexa protectis, dein margine retroflexa et sporangiis mox paginam totam complentibus, 0.3–0.4 mm. altis; annulis obliquis non interruptis.

MINDANAO, Zamboanga, monte Apo, *Copeland* 1509. Ad terram, 1,500 ad 1,800 m. s. m.—COPELAND.

[15] Plagiogyria (1858) 274, No. 5.

"Zamboanga" should have been omitted from the locality given for the type. More recently collected in Mindoro and again in Mindanao; also in Kwangtung, where the specimens agree perfectly in texture and color with those from the Philippines. This and the preceding species are very closely related—perhaps too closely. Judging by the collections to date, *P. christii* has larger fronds, with more numerous pinnæ (13 to 15 on a side) than are usual in *P. euphlebia*, thinner in texture, and distinct in color—very dark green above, paler and somewhat olivaceous beneath—and still laxer venation. Contrary to the published diagnosis, tubercles are present on the enlarged stipe bases, but feebly developed and inconspicuous; also, the lower pinnæ are "breviter," rather than "brevissime," stalked.

3. PLAGIOGYRIA GRANDIS Copeland, sp. nov. Plate 1.

Caudice crasso, erecto; frondis sterilis stipite 40 cm alto, basi trigono-dilatato externe utroque latere 3–4 tuberculis magnis praedito, sursum etiam tuberculis minoribus conspicuis usque ad 20 cm infra pinnas infimas ornato; fronde ca. 60 cm alta, 25–30 cm lata, pinnata cum impari simile, rhachi obtuse angulata, ad basin pinnae quaeque tuberculo minuto praedita; pinnis utroque latere ca. 15, alternantibus, infimis pedicellatis, plerisque sessilibus vel subsessilibus, supremis anguste adnatis, basi cuneato-retundatis, valde et angustissime caudatis, medialibus 20 cm longis, ca. 17 mm latis, infimis paullo minoribus, ubique serrulatis seu cauda remote serratis, papyraceis, olivaceis; fronde fertile ultra 40 cm alta, pinnis 15–20 cm longis, 2–3 mm latis, pedicellatis.

Kwei Chau, Pinfa, leg. Cavalerie; Rosenstock, Fil. Chin. No. 171. Type in the United States National Herbarium, Nos. 1096007, 1096008.

Nearly related to *P. euphlebia* Mettenius, and distributed under that name. It is larger than that species or *P. christii*, not blackish like the latter, and different from both in the finely long-caudate pinnæ, and especially from *P. euphlebia* in the absence of slender pedicels of the pinnæ. Correlated with its size is the strong development of the aërophores, on the flattened base, the rachis, and the upper part of the stipe.

The sporangia are large, with rather conspicuously oblique annulus, with about twenty-two thickened cells. The spores are tetrahedral, and very minutely rough. In and near the axils of the pinnæ there may be a cluster of minute hairs.

4. PLAGIOGYRIA INTERMEDIA Copeland, sp. nov. Plate 2.

Caudice suberecto, plerumque breve; frondis sterilis stipite usque ad 20 cm alto, fulvo, triangulare, basi applanato valde carinato aerophoris paucis et parvis praedito, frondis fertilis ca. 40 cm alto; fronde sterile 25–30 cm alta, ovata, costa superne prominula biangulare et sursum alata, inferne tereta, aerophoris carente; pinnis utroque latere ca. 15, infimis non abbreviatis sessilibus vel subsessilibus, sequentibus anguste adnatis, supremis confluentibus, segmento terminale aliter pinnis simile, medialibus 8–10 cm longis, ca. 12 mm latis, acuminatis, apices versus serratis, alibi integris, papyraceis, olivaceo-viridibus, venis plerisque furcatis; fronde fertile 30 cm alta, pinnis plerisque stipitulatis, 6–10 cm longis, 2–3 mm latis.

Japan. Type, *Faurie 160,* 1907, in herbarium Copeland No. 2742, Koyasan, in petrosis. Also, Yugashima, *Faurie 27,* 1912; Hieisan, Mrs. Knowlton; Oldham, 1862, ex Herb. Kew.

This species is intermediate between *P. euphlebia* and *P. adnata.* I have received it under both names, but the specimens in the United States National Herbarium all bore the former. It differs from this in the confluence of the upper pinnæ and adnate or sessile lower ones. It differs from *P. adnata* in the less adnate pinnæ and the absence of the marked tendency of their bases to run up the rachis. It is approached by *P. adnata* var. *distans.*

5. PLAGIOGYRIA PYCNOPHYLLA (Kunze) Mettenius.

Plagiogyria pycnophylla (Kunze) METTENIUS, Plagiogyria (1858) No. 2.

Lomaria pycnophylla KUNZE, Bot. Zeit. 6 (1848) 143.

Fronde tenuiter coriacea, opaca, glabra, subconcolore, oblongo-lanceolata, breviter acuminata, pinnata; pinnis sessilibus, approximatis, frondis sterilis patentibus lanceolatis, acuminatis, basi exciso-cuneata integerrimis, margine reliquo reflexo serrulatis, costa tenui, subtus sulcata, venis arctis, furcatis, supra prominulis, infimis abortivis; rhachi validiuscula, depressa, marginata, supra canaliculata, subtus bisulcata; frondis fertilis pinnis erecto-patentibus, linearibus, basi rotundata uniglandulosis, apice obtusiusculis; soris costam non obtegentibus; rhachi angulata, utrinque bisulcata; rhachibus stipiteque mediocri utriusque frondis rufescentibus, glabriusculis; caudice scandente sparsim paleaceo.

Ex insula Java communicavit cl. de Vriese (sub. L. scandente W.).
—METTENIUS.

Outside of Java, this is known from several mountains of Borneo and Luzon, where it is very abundant locally, and from southern and western China and northern India, where again it is locally common. The variety *mixta,* described from Luzon,

is no more than a local freak. The variety *remota* is a large form, such as seems to be commoner in India, found in Luzon only in sheltered spots.

This is like the preceding species and those immediately to follow, and unlike the majority of the genus, in being really pinnate unless immediately under the apex, where a few small "pinnæ" are united at their bases. It has uniformly smaller pinnæ than the preceding species, more coriaceous in texture, more evidently toothed, with more congested venation, and is most distinct in that the sterile pinnæ are truncate at their bases, and sessile, or the lowest very short-stalked, and these often deflexed, but not much reduced in size.

The stipes of the sterile fronds are often less than 10 centimeters long, but may reach several times this figure. The fronds are 30 to 60 centimeters long, or still longer, but most commonly near the smaller figure. The pinnæ are twenty or more on a side, usually separated by much less than their own width, usually acute and sharply serrate, but varying from obtuse to acuminate and subfalcate. In stunted, alpine forms, the pinnæ are obtuse, and may be almost entire. Typically, a small tubercle subtends each pinna, but this may be quite absent. Even the apex of the frond may not be constant; typically, it is pinnatifid, merging at the bottom into the fused upper pinnæ; but there are rare specimens, given this name, with an apical leaflet quite like the lateral ones.

The rachis and the upper part of the stipe are square in section, and range in color from stramineous to brown. The stouter and darker they are, the more likely are the tubercles to be evident.

6. PLAGIOGYRIA TUBERCULATA Copeland.

Plagiogyria tuberculata COPELAND, Philip. Journ. Sci. Suppl. 1 (1906) 153.

Rhizomate erecto, breve, valido; stipitibus permultis confertis, frondium sterilium 20–35 cm., fertilium 30–40 cm. altis, rhachibusque quadratis glabris nitidis rubido-brunneis basibus incrassatis aerophora ca. 12 ferentibus; rhachi infra insertionem pinnae tuberculum 1–1.5 mm. longum durum emittente, nec stipite eisdem minoribus remotis carente; fronde sterile ca. 60 cm. alta, 20–25 cm. lata, abrupte acuminata; pinnis 30–40-jugatis, fere horizontalibus, inferioribus brevi-pedicellatis basibus acutis, superioribus adnatis, supremis coadunatis, acuminatis apicibus rectis serratis, aliter integris, majoribus ca. 12 mm. latis, papyraceo-coriaceis, glabris; venulis simplicibus vel furcatis conspicuis; fronde fertile angustiore, mox desiccante, pinnis ca. 11 cm. longis, 2–3 mm. latis, patentibus.

LUZON, Lepanto, Bagnen, 1,900 m. s. m., *Copeland* 1924.—COPELAND.

Later collections extend the range of this species to Negros and Mindanao, and to Borneo and Sumatra. What was described as *P. pycnophylla* var. *integra* Copeland, Philip. Journ. Sci. § C 5 (1910) 285, is really a small *P. tuberculata.*

Plagiogyria tuberculata is a notably large fern, characterized by its shiny, dark stipes and rachises, from reddish brown to dark purple in color. This is an expression of the strong development of an impervious layer of mechanical tissue, in correlation with which the aërophores are remarkably developed, not merely subtending the pinnæ, but also on the stipe, for some distance below any pinna. The subcoriaceous, light green pinnæ are entire except at the apex. The lower ones are contracted on both sides and stalked, as in *P. euphlebia;* in the upper third, or sometimes two-thirds, of the frond, they are more or less completely adnate. The apex is typically and usually pinnatifid, but in a few specimens seen, not otherwise distinguishable, it is a simple leaflet or has one basal branch.

The var. *latipinna* Copeland, Philip. Journ. Sci. § C 2 (1907) 133, is a congested alpine form from Mount Halcon; in sheltered places near at hand grew fronds more ample than the typical. A slender form, from Negros, has been called var. *gracilis* Copeland, Elmer's Leaflets Philip. Bot. 2 (1908) 405.

PLAGIOGYRIA SUMATRANA Rosenstock, Fedde's Repert. 13 (1915) 214.

Rhizomate erecto, stipitibus fasciculatis (ad 10), brunneis, nitidis, profunde canaliculatis, basi dilatata exteriore tuberculis 1–2 utrinque instructa, foliorum sterilium ad 20 cm., fertilium ad 40 cm. longis; laminis sterilibus ad 50 cm. vel ultra longis, 18 cm. latis, elongato-oblongis, breviter acuminatis, subcoriaceis, laete viridibus, glabris, pinnatis; pinnis c. 25-jugis, alternis, erecto-patentibus, aerophoro tuberculiformi basi instructis, sessilibus vel inferioribus breviter petiolatis, superioribus basi infra late decurrenti adnatis, summis paucis inter se et cum pinna terminali, basi paucilobata, confluentibus; medialibus maximus c. 10 cm. longis, 1½ cm. latis, e basi cuneata oblongo-lanceolatis, acuminatis, margine indistincte crenulatis, versus apicem crenulato-serratis, inferioribus decrescentibus, basalibus c. 5 cm. longis; nervis patentibus, simplicibus vel furcatis; laminis fertilibus sterilibus subaequalibus vel latioribus, pinnis patentibus, ad 15 cm. longis, 3–4 mm. latis.—ROSENSTOCK.

Sumatra.

This is described as distinguished from *P. pycnophylla* by having a considerable part of the sterile pinnæ adnate and decurrent; from *P. tuberculata,* by having fewer tubercles, firmer texture, and erecto-patent, instead of almost horizontal, pinnæ.

As the cotype, Rosenstock, Fil. Sumatranae No. 127, United States National Herbarium No. 1096063, is not firmer in texture than *P. tuberculata* often is, and has four aërophores on each

side of the base, these distinctions do not seem to be constant; but the fertile pinnæ are wider than on any of my specimens of *P. tuberculata.* I do not regard them as distinct species.

7. PLAGIOGYRIA GLAUCA (Blume) Mettenius.

Plagiogyria glauca (Blume) METTENIUS, Plagiogyria (1858) 273.
Lomaria glauca BLUME, Enumeratio (1828) 204.

L. frondibus pinnatis, pinnis sesilibus sterilibus lineari-lanceolatis acuminatis basi rotundatis vel subcuneatis serrulatis glabris subtus niveis, terminalibus subadnatis, fertilibus angusto-linearibus, sterilium rachi marginata, stipite subtetragono glabro . . . Crescit in umbrosis Javae interioris.

Var. B. frondis sterilis pinna ultima subpinnatifida.

Crescit in silvis montis Gede.—BLUME.

This is probably the commonest, as well as the most beautiful fern in its genus. North of Java, Celebes, and Borneo, it is found on most Philippine mountains, and in Formosa, Yunnan, and Khasya.

It is very nearly related to *P. pycnophylla,* from which it shows no constant difference except in the glaucous coating of the back of the sterile fronds. Even this is variable. Sometimes it is thin enough for the green to show through; but as a rule it is dense enough to make the entire surface a clear color of its own, whether snowy white or pale blue. As Blume already knew, the form of the apex of the frond is unstable—about equally often a leaflet like the lateral ones, and a serrate-lobed apex formed by the fusion of potential leaflets.

Plagiogyria glauca varies conspicuously in the course of its range. In Java, where first described, it is a very large fern, said to reach a height of 150 centimeters, with pinnæ up to 2 centimeters wide, with caudate, very coarsely toothed tips, and not at all thick or hard. Mindanao plants are smaller, but not very different. In northern Luzon, the common form is Christ's var. *philippinensis,* much smaller, not at all caudate, and rigidly coriaceous; and this is the form known to me from the Himalayas. I would be disposed to distinguish it specifically, if sure I had not already done so, by the description of *P. nana,* to which Christ's variety is at any rate very close.

Inspection of the type of *Lomaria* (?) *lucida* Presl, Rel. Haenk. 52, might show that the name of this species requires change.

8. PLAGIOGYRIA NANA Copeland.

Plagiogyria nana COPELAND, Philip. Journ. Sci. § C 4 (1909) 114.

Plagiogyria gregis P. glaucae Mett. qua statura reducta, pinnis rigidis confertis obtusis conspicue differt. Stipite frondis sterilis 3–5 cm alto, frondis fertilis circiter 15 cm, aerophoris paucis; fronde sterile 10–13 cm

alta, 5–6 cm lata; pinnis approximatis vel infimis paullo remotis, fere omnibus liberis, sessilibus, circiter 6 mm latis, obtusis, minute serrulatis, rigide coriaceis, infra glaucis; fronde fertile circiter 10 cm alta, sat condensata, pinnis 25–35 mm longis, linearibus, falcatis.

LUZON, Province of Benguet, Mount Pulog, *For. Bur. 16306 Curran, Merritt, & Zschokke*, common in grass lands, altitude 2,850 m, *Copeland P. P. E. 113.*

This is conceivably a form of *P. glauca*, due to the very unusual environment, but is distinct in various respects beside the stature. Specimens growing in brush are of course decidedly less dwarfed, but they are still far from typical *P. glauca*.—COPELAND.

9. PLAGIOGYRIA EGENOLFIOIDES (Baker) Copeland.

Plagiogyria egenolfioides (Baker) COPELAND, Journ. Straits Br. R. As. Soc. No. 63 (1912) 72.

Lomaria egenolfioides BAKER, Kew Bulletin (1894) 7.

Caudice erecto, frondibus biformibus dense caespitosis subcoriaceis glabris lineari-oblongis simpliciter pinnatis, stipitibus elongatis gracilibus brunneis nudis frondorum fertilium longioribus, pinnis sterilibus linearibus obtusis crenatis basi utrinque auriculatis, inferioribus deflexis sensim minoribus, venis remotis erecto-patentibus immersis obscuris superioribus simplicibus inferioribus furcatis, pinnis fertilibus remotioribus multo minoribus . . . . Lamina sterilis 5–6 poll. longa, medio 12–15 lin. lata, stipite 1½–2-pollicari. Lamina fertilis 8–9 lin. lata, stipite 4–5-pollicari.—BAKER.

Sarawak, Mount Dulit.

This species gets its name from the strong superficial resemblance to *Egenolfia appendiculata.*

10. PLAGIOGYRIA MINUTA Copeland. Plate 3.

Plagiogyria minuta COPELAND, Philip. Journ. Sci. § C 10 (1915) 148.

Rhizomate erecto, breve, radicibus et basibus frondium densissime vestito; fronde sterile ca. 6 cm alta, 10–12 mm lata, stipite usque ad 1 cm alto et deorsum rachi quadrangulatis minute paleaceis; pinnis multis, alternantibus, sessilibus, 6 mm longis, 1.5–2 mm latis, obtusis, crenatis, coriaceis, glabris; venis simplicibus, utroque latere costae 3 vel 4; frondis fertilis stipite 3 cm alto, pinnis paucis, stipitatis, 2–3 mm longis, 1.5–2 mm latis, cordatis, margine retroflexa lata; annulo continuo, cellulis ca. 26.

Sarawak, locality unknown, native collector *No. 393.*

An evident and near relative of *Plagiogyria egenolfioides* (Baker) Copel. . . ., but much smaller throughout, and the sterile pinnae usually narrowed at the base instead of cordate or auricled.—COPELAND.

I have not now at hand a specimen of *P. egenolfioides*, but did have when describing *P. minuta.* The latter is now illustrated by the accompanying Plate 3. The two species represent a very distinct group, known only in Borneo. A similar local group is composed of the next two species.

11. PLAGIOGYRIA ROTUNDIPINNATA Bonaparte.

Plagiogyria rotundipinnata BONAPARTE, Notes Ptérid. No. 14 (1925) 484.

Stipite plusquam 20 cm alto, rhachique teretibus, purpureis vel castaneis, glabris, superne sulcatis; fronde sterile usque ad 30 cm alta, 8 cm lata, lanceolata-ovata, utrinque angustata, in pinnam aliis similem 8 cm longam desinente; pinnis lateralibus erecto-patentibus, lanceolatis, apices rotundatis versus attenuatis, basibus truncatis, tuberculis rhachi excrescentibus subtensis, basibus subdistantibus, deinde ob formam lanceolatam pinnarum contiguis, integris, coriaceis, costis inferne prominentibus, interdum purpureis; nervis aut simplicibus aut furcatis, inferne conspicuis; pinnis supremis adnatis, infimis sessilibus vel breviter stipitulatis; fronde fertile simile, pinnis utroque latere usque ad 25, 7 cm longis, 3 mm latis, ita fastigiatis ut frons linearis videtur.

Sarawak, summit of Mount Murud, altitude 2,400 meters.

12. PLAGIOGYRIA CLEMENSIAE Copeland, sp. nov. Plate 4.

Caudice et pede stipitis ignotis; fronde ca. 40 cm longa, 15 cm lata, rhachi fusca, valida, usque ad 10 mm crassa, ad basibus pinnarum tuberculis parvis nigris praedita, haud angulata nec carinata; pinnis permultis, imbricatis, infimis foliaceis 4 cm longis sessilibus, infra easdem auriculis minutis remotioribus pinnas substituentibus, medialibus 9 cm longis, 8 mm latis, de basi ad apicem rotundatam sensim angustatis, contiguis et deinde imbricatis, ad rhachin ipsam confluentibus, integris, coriaceis, foliola apicale lateralibus simile sed minore; costis utraque facie prominentibus; venis fere omnibus simplicibus; fronde fertile subaequale; pinnis utroque latere interdum ultra 50, medialibus 5–8 cm longis, anguste linearibus, inferioribus sessilibus, superioribus dilatato-adnatis, aut rectis et horizontalibus aut sinuatis aut valde incurvatis, margine scario mox retroflexo et pinnis deinde ut videtur ubique (ad ambas facies) fructiferis, soris confluentibus.

Borneo, Mount Kinabalu, at Paka Cave, altitude 3,000 m. s. m.

Originally identified and distributed as *P. adnata,* from which it is quite distinct, in fact and in appearance. It is, however, very near the preceding species, from which it seems to differ in the remarkably congested foliage and abortive basal pinnæ. To guard priority for Bonaparte's name, if the two species prove

eventually to be one, I have provided it with a Latin translation of his description, and given it priority of place here. Really, though, the publication of a French or English or German description shows the same contempt, both for rules and for the convenience of botanists the world over, as would the use of Russian or Japanese for the same purpose; and I propose, when it again becomes necessary for me to treat the plants in a case like this, to treat the vernacular description as without effect.

13. PLAGIOGYRIA ADNATA (Blume) Beddome.

Plagiogyria adnata (Blume) BEDDOME, Ferns Brit. Ind. (1865) pl. 51.
Lomaria adnata BLUME, Enumeratio (1828) 205.

L. frondibus pinnatis glabris, sterilibus sessilibus acuminatis basi sursum adnatis deorsum rotundatis apice dentatis, fertilibus breviter petiolatis angusto-linearibus, rachi stipiteque tetragonis glabris. . . . Crescit in sylvis montanis Karang Javae insulae.—BLUME.

Java, Sumatra, Borneo, Philippines, Formosa, Kwangtung, Yunnan, Khasya. Also reported from Japan, but the specimens I have received thence so named are *P. intermedia*.

The sterile fronds are, of course, not sessile, Blume's statement applying to their pinnæ. The stipes are 20 to 30 centimeters or more in length, slender, brown or maroon toward the base, the bases moderately dilated, with two to five small tubercles in each row. The upper part of the stipe is obscurely, and the lower part of the rachis more sharply, 4-angled, the upper face wider than the lower; upward, the angles flatten out beneath, but the axis is prominent above throughout, and somewhat channeled. The lower pinnæ of ample fronds are separated by more than their width, and the upper ones by less. The larger ones are up to 8 centimeters long on large fronds, and to 15 millimeters wide, but usually more slender, about horizontal in position, moderately curved carrying the tip upward, the lowest little or not at all reduced, usually acute but varying from obtuse in small forms to acuminate, sharply serrate at the apex, elsewhere serrulate or entire; the bases, as described by Blume, cut away quite to the costa in the lower side in the lower part of the frond, but the adnate upper side running up the rachis as a wing; farther up the frond, the lower side of the pinna gradually becomes adnate, and the wing stretches out to reach the succeeding pinna; and near the apex the pinnæ are broadly adnate, and separated by rounded sinuses. The apex is an acute or acuminate segment, sometimes shading through lobes into the adjacent lateral ones, sometimes broadly and obscurely lobed.

The texture is thinly coriaceous; color, clear or slightly brownish green on both sides; venation, lax, with almost all the veins forked.

Fertile fronds longer-stalked and a little smaller; the pinnæ narrowly linear, stalked in the lower part of the frond, then adnate, and dilated-adnate at the top. Tips of the fertile veinlets free. Sporangia about one-third millimeter long, on shorter stalks of about six rows of cells. Annulus variable, usually of a little over thirty cells, of which six to ten flattened ones represent the stomium. Spores tetrahedral, minutely warty. Open and immature sporangia are found together, but without very young ones in my observation.

Plagiogyria adnata occupies a central position in the genus, connecting the groups with free pinnæ with the larger one, typically extra-Malayan in its distribution, with confluent segments.

Rosenstock [16] describes two varieties:

distans, the lower pinnæ contracted at the base, not running up the rachis. KweiChou, AnHwei and CheKiang.

angustata, the lamina 60–70 cm. long, 5–8 cm. wide, with about 40 pinnæ on each side. In KweiChou.

PLAGIOGYRIA RANKANENSIS Hayata, Icones Form. 8 (1919) 151.

Rhizoma erectum plus minus ascendens. Stipes 13–14 cm. longus triangularis in sectione basi dilatatus subcomplanatus basi plus minus squamatus. Frons sterilis lineari-triangularis 30 cm. longa 18 cm. lata apice in ambitu cuspidata basi truncata pinnata, pinnis inferioribus longioribus, infimis plus minus reflexis, inferioribus horizontaliter patentibus linearilanceolatis 9 cm. longis 12 mm. latis apice acuminatis ad summum obtusis basi lateris inferioris valde contractis sed basi lateris superioris ad rhachin frondis decurrentibus margine minute denticulatis sursum ad acuminem serrulatis; textura tenuiter chartacea, rhachis frondis complanata anguste alata. Frons fertilis 30–40 cm. longa remote pinnata, pinnis linearibus crispato-recurvatis 5–10 cm. longis 1 mm. latis.

Formosa, Rankanzan, alt. 4900 ped.

Near *P. adnata* Bedd., but separable from it by the distinctly winged rhachis and much smaller terminal pinna.—HAYATA.

As *P. adnata* has the rachis winged the most of its length, and its apical segment is always small, it seems probable that *P. rankanensis* is not in fact distinct from it. We have a Formosan specimen, determined as *P. rankanensis* by Sasaki, which I take for a large *P. adnata*. The identification, already noted, of a distinct Japanese plant as *P. adnata* might very easily result in the demand for a new name for *P. adnata* itself.

[16] Fedde's Repert. 13 (1913) 122.

ad auriculas 3 mm longas 5 mm latas reductis, sequentibus horizontalibus, medialibus maximis horizontali-patentibus 3–3.5 cm longis, praecipue apices versus minute serratis, basibus adnatis ca. 7 mm latis contiguis et inter se sinubus angustis acutis separatis, deinde ad apices acutas sensim angustatis, tenuiter papyraceis, olivaceo-viridibus; venis tenuibus prope rhachin furcatis alibi plerisque simplicibus; fronde fertile 15–20 cm longa, pinnis anguste linearibus, stipitulatis, majoribus ca. 5 cm longis, 2–3 mm latis.

Indo-China, Chapo, leg. Petelot No. 1656, July, 1924. Chapo is on the Yunnan border, and this is credited to China in the table of distribution of species.

This species is clearly characterized by its general slenderness, of the stipes and their bases, of the sterile fronds, and of the fertile pinnæ, as well as by the violent contrast in the length of the stipes of the sterile and fertile fronds.

Sporangia 0.30 to 0.35 millimeter long; annulus of about twenty thickened cells and ten to twelve flattened ones; spores tetrahedral to 4-lobed, minutely rough.

18. PLAGIOGYRIA FALCATA Copeland.

Plagiogyria falcata COPELAND, Philip. Journ. Sci. § C 2 (1907) 133, pl. 1, B.

Caudice erecto, 5 mm. crasso, basibus stipitum persistentibus profunde obtecto; stipitibus confertis frondium sterilium 7–10 cm., frondium fertilium 16–24 cm. altis, glabris, deorsum triangulatis, pedibus incrassatis aerophoris carentibus; fronde sterile ca. 20 cm. alta, 6–7 cm. lata, brevi-acuminata, fere vel usque ad rachin pinnata; pinnis proximis, adnatis nec basibus dilatatis, acutis, ca. 5 mm. latis, rectis vel subfalcatis, argute serratis vel rhachin versus integris, inferioribus valde deflexis, membranaceis, glaberrimis, nigro-viridibus; venulis conspicuis, fere semper simplicibus; fronde fertile 15–24 cm. alta, 2.5–4 cm. lata, acuminata, pinnata; pinnis falcato-arcuatis, 2–3 cm. longis, 2 mm. latis, inferioribus remotis.

—COPELAND.

Mindoro, Mount Halcon, 2,100 m. s. m., *Merrill 5960.*

Still known only from the type collection. Regarding the report of this species in Formosa, see note under *P. hayatana.*

This is the only species with practically all the veins of the sterile frond simple. Among the species with all the pinnæ or segments adnate, and especially among those with thin fronds, it is also notable for the dark color of both surfaces.

The fertile veins fork very close to the costa, and their thickened tips are free. Sporangia 0.25 millimeter long, on slender stalks of not more than five rows of cells; annulus of twenty to

twenty-four thickened cells and ten to twelve flattened ones; spores very strongly 4-lobed, apparently smooth.

Reëxamination, on the assumption that aërophores must be present, reveals specks on some of the bases; but only an examination made in that spirit detects any sign of them.

19. PLAGIOGYRIA TENUIFOLIA Copeland. Plate 7.

Plagiogyria tenuifolia COPELAND, Philip. Journ. Sci. § C 3 (1908) 281.

Stipitibus frondis sterilis 15 cm fertilis 25 cm altis rhachibusque glabris brunneo-stramineis, acute trigonis; fronde sterile oblonga, 16–20 cm longa, 8–9 cm lata, vix ad rhachidem in pinnulis adnatis partita; pinnulis medialibus 4–4.5 longis, 8 mm latis, acutis, apicem versus grosse obtuse serratis, sinubus angustis interpositis, pinnulis inferioribus paullo reductis, infimis valde deflexes, glabris, herbaceis; fronde fertile ca. 10 cm alta, pinnis utrinque ca. 12, 2–2.5 cm longis, inferioribus stipitatis, rhachidem versus haud hastatis; annulis non interruptis.

Ma On Shan, 450 m. s. m. *Matthew 51.*—COPELAND. [Kwangtung Province, China.]

Fertile pinnæ up to 2.5 centimeters long and 3 millimeters wide, obtuse. Sporangia 0.3 millimeter long, open and immature ones mixed. Annulus of eighteen to twenty thickened cells and eight to ten stomium cells, the two kinds meeting, below, at the side of the insertion of the pedicel. Spores convex-tetrahedral.

This is distinguished from the others in its group by its broad, short fronds. The linear, but not narrowly linear, fertile pinnæ suggest the American species, but the texture and serration are distinctively Chinese.

20. PLAGIOGYRIA HAYATANA Makino.

Plagiogyria hayatana MAKINO, Tokyo Bot. Mag. 23 (1909) 245.

Rhizome erect, or ascending. Stipes triquetrous, exalate, shorter than the frond, about 12–20 cm. long, the base depressed-triquetrous and more or less dilated. Frond glabrous, more or less firm, oblong or narrowly oblong, acuminate, very deeply pinnati-parted, 30–50 cm. long, 12–17 mm. broad; segments numerous, close but sometimes subremote, patent or patent-divergent, but usually somewhat reflexed in basal ones, linear-lanceolate, subfalcate, acuminate, slightly dilated at the base, serrulated (the serration more conspicuous towards the apex), attaining about 9 cm. long, 1 cm. broad; midrib prominent on both sides; veins patent-divergent, bifurcate, simple in the superior ones; rachis carinate throughout beneath. Fertile fronds exceeding the sterile ones, long-stiped; pinnae remotely and simple-pinnately disposed, not secund, a little dilated and adnate at the base, angustate, patent or erecto-patent, the lower ones reflexed.

—MAKINO.

Formosa; also, China, as noted below.

The key that accompanies this description distinguishes this species from *P. matsumureana* by the flat back of the rachis of

the latter; and both of these from *P. stenoptera* by the criteria that the latter has the fertile pinnæ stalked, and the lower sterile pinnæ exceedingly reduced. A more significant difference from *P. matsumureana* is the absence of the toothed teeth of the latter.

Our authentic specimen of this fern, received with Sasaki's determination as *P. falcata*,[18] has only sterile fronds. It is not as slender a fern as *P. falcata*, nor as dark, has more-pointed leaflets, and differs most conspicuously in the venation. Judging by the fronds at hand, the segments of the sterile frond are variable in width as well as in closeness.

Without entire confidence, I identify with this a specimen collected in Anhwei by R. C. Ching, herbarium of the University of Nanking No. 8787. The sporangium is 0.3 to 0.4 millimeter long, with a stalk of five rows of cells. The annulus has about twenty thickened cells, and twelve conspicuously flattened stomium cells, the latter extending past the insertion of the pedicel, so that the sporangium ruptures very near its base.

21. PLAGIOGYRIA DUNNII Copeland.

Plagiogyria dunnii COPELAND, Philip. Journ. Sci. § C 3 (1908) 281.

Stipite frondis sterilis 20–25 cm alto glabro, ad basin aerophoris paucis donato, brunneo-bialato, rhachideque acute carinatis; fronde 40 cm alta, 10 cm lata, acuminata, fere ad rhachidem pinnatifida; pinnis medialibus 5 cm longis, 5 mm latis, plerumque rectis, acuminatis, apices versus serrulatis, glabris, tenuibus, sinubus latitudine pinnas saepe superantibus separatis, inferioribus plus minus diminutis, paullo deflexis, supracurrentibus; fronde fertile 25 cm alta, pinnis pede sterile adnatis, utroque latere plusquam 35, infra mediam frondem 5 cm longis sursum sensim decrescentibus.

Ad montem Yenping, 900 m. s. m. *Dunn 9934*.—COPELAND. [Fokien Province, China.]

The sporangia of the type, which is the only collection to date, are immature. As they are, they are a scant quarter millimeter in length, and the stomium cells, not yet fully differentiated, appear to be placed as in most other species, so that the rupture of the sporangium will not take place as close to the base as in the Anhwei plant just described. Too few species and specimens have been examined to establish the stability of this character.

This and the preceding species are very much alike. The segments of the sterile frond of *P. dunnii* are more remote, separated by almost their own width even close to the apex; but

[18] Cf. Icones Form. 4 (1914) 239.

still the affinity is very marked. *Plagiogyria dunnii* is the older name.

22. PLAGIOGYRIA ARGUTISSIMA Christ.

Plagiogyria argutissima CHRIST, Bull. Acad. Geog. Bot. Mans 20 (1910) 141, pl. 2.

Très voisin de *P. semicordata* (Presl) des Andes de l'Amérique.

Stipite pennae corvinae crassitie, rufo supraque cum rachi fulvo-stramineo, 7 cent. longo, lamina sterili oblonga acuminata deorsum angustata et in meras auriculas trigonas laceratas 5 mill. longas desinente, 40 cent. longa, media 10 cent. lata, pinnata, fere ad rachim divisa, pinnis pectinato-confertis recte patentibus, inferioribus abbreviatis deflexis, 35 utrinque, 5 cent. longis, 1 cent. latis, late et aequaliter adnatis, cuspidatis, acutissime biserratis, nervis manifestis sed tenuissimis ca. 20 utrinque, plerumque a basi aut medio furcatis.

Lamina fertili ad basin iisdem auriculis ac in lamina sterili instructa, pinnis contractis remotis linearibus, inferioribus stipite tenui ½ cent. longo praeditis et ex auriculis dilatatis et decurrentibus emergentibus 5½ cent. longis 2 mill. latis acuminatis, superioribus sessilibus. Sporangiis faciem inferiorem tegentibus, fulvis. Textura flaccide herbacea tenui, colore laete virente, faciebus glabris.

Hab. Rivière Taitchen (Pin-fa) décembre 1908, N. 3392, leg. Cavalerie.—CHRIST.

Known to me only by this description, which makes it seem to be a very distinct species.

23. PLAGIOGYRIA MATSUMUREANA Makino.

Plagiogyria matsumureana MAKINO, Tokyo Bot. Mag. 8 (1894) 333.

Caudex short, robust. Fronds dimorphous. Stipes fasciculate, rather stout, naked, 7–10 cm. long, but those of fertile ones longer, the base triquetrous, dilated, subcarnose, and furnished with a few minute glands. Sterile fronds pinnatipartite almost to the rachis, oblong-lanceolate, 30–50 cm. long, 10–17 cm. broad; segments numerous, approximate, horizontally patent, linear-lanceolate, acuminate, acutely duplicato-serrate, membranaceous; middle segments the largest, 5–8 cm. long, 7–14 mm. broad. Veins forked, erecto-patent; venules free, fine, sometimes forked. Fertile fronds pinnate, lanceolate; pinnae distant, mostly alternate, patent, contracted into elongated narrow-linear with acutely obtuse apex, the base dilated and adnate to the rachis. Sori linear. Indusium narrow, membranaceous.—MAKINO.

Japan, Shinano, Mount Komagadake (type locality), and in many other places. The fern once reported in Formosa under this name is *P. hayatana.*

Apparently identical with this is—

Lomaria (*Plagiogyria*) *fauriei* CHRIST, Bull. Boiss. 4 (1896) 666.

Stipe anguleux, jaunâtre, à base enflé, noire, à écailles claires peu nombreuses, subulées. Plante glabre, vert-jaunâtre. herbacée.

Fronde stérile, longue de 45 cm., large de 10 cm. ovée-oblongue, acuminée. Rachis non ailé. Pinnae se racourcissant assez brusquement vers la

base de la fronde, nombreuses (40 à 45 de chaque côte), sessiles sur un rachis à large base, très serrées de manière à ne pas laisser de sinus entre elles, se touchant par les bords, longues de 5 cm., larges de 1 cm., lancéolées-linéares, acuminées en pointe fine, bidentées, à dents aigues et souvent bifurquées. Nervures visibles mais non saillantes, assez serrées, bifurquées à la base. Fronde fertile à pinnae plus distantes, étroites, linéaires. [Here follows comparison with *P. semicordata.*]

Doit être également assez près de Blechnum stenopterum Hance, de Formose, qui m'est inconnu. [Here follow comparisons with *P. adnata* and *P. euphlebia.*]—CHRIST.

I have an excellent specimen of this fern from Faurie, his No. 5613, first identified as *P. matsumureana* and then changed to *L. fauriei;* the fronds are larger than indicated by either diagnosis, but otherwise it conforms perfectly to that of *P. matsumureana.* It may be noted that, while Christ avowed his ignorance of *P. stenoptera* when publishing *L. fauriei,* there is no indication that he was cognizant at all of *P. matsumureana.* Three years later, in publishing *P. henryi,* he was silent about *P. stenoptera.*

Each exterior face of the enlarged stipe base bears one or two inconspicuous aërophores. Sporangium, 0.25 to 0.3 millimeter long; annulus of about twenty-two thickened cells, the flattened stomium cells less differentiated than in most Oriental species, apparently eight to ten; spores tetrahedral to moderately 4-lobed.

This is not only more like the American *P. semicordata* than is any Oriental species; it is more like *P. semicordata* than it is like any other species in its own part of the world. The irregular double serration is a very conspicuous common character.

DOUBTFUL SPECIES

PLAGIOGYRIA SCANDENS Mettenius, Plagiogyria (1858) No. 4.

Truncus?; folia coriacea, glabra, difformia, pinnatisecta, apice?; segmenta sessilia, infra ad insertionem aërophoro exserto aculeiformi vel rotundato instructa, ala angustissima decurrentia, inferiora remota abortiva; foliorum sterilium petiolus 9″ longus, lamina ovato-oblonga, segmenta 8–10 juga, patentia, 3½″ longa, 6‴ lata, e basi inferiore?, superiore truncata, oblongo-lanceolata, acuminata, acute dentato-serrata; nervi secundarii prominuli, ¾‴ distantes, sub angulo 70° decurrentes; foliorum fertilium segmenta breviter petiolata, 4–5″ linga, 2–3‴ lata, flaccide curvata, linearia, margine attenuato integerrima; nervi secundarii prominuli, arcu intramarginali anastomosantes; sori partes supremas nervorum occupantes, denique confluentes.

Stenochlaena Griff. in herb. Kunzea.

Khasya (Griffith).—METTENIUS.

This was construed as *P. adnata* by Hooker and by Beddome, and is reduced to *P. pycnophylla* by Christensen; I do not know

if either identification is sanctioned by consultation of the original plant. The sessile segments, and especially the aërophores on the rachis, support the judgment of Christensen, but the abortive lower segments do not, nor does the marginal veinlet of the fertile pinnæ.

THE AMERICAN SPECIES OF PLAGIOGYRIA

Plagiogyria has been represented in the American Tropics by two species recognized as such, with the following names:

1. PLAGIOGYRIA SEMICORDATA (Presl) Christ, construed as including—

Lomaria pectinata Liebmann.
Lomaria arguta Fée, which I try to construe.
Lomaria fialhoi Fée et Glaz.
Plagiogyria biserrata Mettenius.

2. PLAGIOGYRIA COSTARICENSIS Mettenius: Kuhn.

This species is unknown to me. It may have been collected only once; and it is not too certainly a *Plagiogyria*. Mettenius should, indeed, have judged competently in this matter, but his specimen was destitute of caudex and stipe; the sporangia are not mentioned by him; and the description of the venation strongly suggests another genus.

To these two may be added—

3. BLECHNUM URBANI Brause.

These ferns are evidently not rare, from central Mexico and Porto Rico to Bolivia. In spite of the difficulty which all dimorphous ferns present to collectors, they are numerous in herbaria, always as *P. semicordata* or *P. biserrata,* however various in appearance. They constitute, indeed, a far more homogeneous group than do the Oriental species of the genus, and, as already indicated, a younger group, naturally less rich in species. Still, I am unable to regard nearly all of the ferns ticketed with these names as reasonably to be regarded as a single species.

The comparative homogeneity of American, as contrasted with Oriental *Plagiogyria,* is shown first by the common frond design of all the species—that of the group typified in the Orient by *P. adnata,* carried to America in somewhat the form of *P. matsumureana.* Beside this, the American species seem all to be less woody than are many of the Oriental ones. Their enlarged stipe bases, and the stipes and rachises, must be rather fleshy when fresh; for they collapse in drying, so that the bases, in herbarium specimens, are flattened, rather than three-ridged. Corresponding with this peculiarity of the texture, there is a

comparative absence of aërophores. I can find no trace of them on the rachis of even the stoutest American species; and on the enlarged bases, they are invisible on some, and hardly more than suggested, if present at all, on others.

With the limited material previously available, I had prepared a description of one species (which I now construe as *P. arguta*) and been content with noting others as not properly *P. semicordata*. With the far richer collection of the United States National Herbarium in hand, I now undertake to describe the most clearly marked other species. This treatment is still not exhaustive, even as to the plants in hand; but I am constrained to leave the work in this unfinished condition, by uncertainty as to what is properly referable to the old species. As will be noted presently, when the diagnoses are quoted, Presl, whose specific name has been so widely applied, had for description only a fragment, which probably would not permit positive identification with any complete plant, even if it were available for comparison. Since the name can hardly be discarded, no better course is left than to follow precedent, and accept *P. biserrata* Mettenius as a synonym, thereby getting Mettenius's description, figures, and plants as bases of identification. As a rule, when Mettenius described a plant, it can be identified, but in this case, not having his specimens as evidence, I suspect that he did more than describe a plant—that he described two of them. Until this question can be cleared up, I am leaving *P. semicordata* a "collective species," but a far more homogeneous one than I have found it.

Key to the American species of Plagiogyria.

1. Margin of segments or pinnæ entire ..... 32. *P. costaricensis.*
1. Margin subentire, pinnæ long-acuminate ..... 31. *P. urbani.*
1. Margin denticulate ..... 29. *P. denticulata.*
1. Margin serrate, teeth not very unequal.
   2. Pinnæ or segments obtuse ..... 30. *P. obtusa.*
   2. Pinnæ acute or acuminate ..... 25. *P. semicordata.*
1. Margin serrate, teeth not uniform.
   2. Frond gradually much narrowed below.
      3. Lowest pinnæ quite remote ..... 24. *P. arguta.*
      3. Lowest pinnæ not very remote ..... 25. *P. semicordata.*
   2. Base not much narrowed; large ferns.
      3. Base of many fertile pinnæ abruptly narrowed on both sides. 26. *P. anisodonta.*
      3. Most bases not dilated on lower side.
         4. Veins near rachis only once forked ..... 27. *P. maxoni.*
         4. Some twice-forked veins everywhere ..... 28. *P. latifolia.*

24. PLAGIOGYRIA ARGUTA (Fée) Copeland, comb. nov. Plate 8.

Lomaria arguta FÉE, Huitième Mémoire (1857) 70.

Frondes stériles lancéolées, glabres, à segments profondément dentés, dents en scie; les fertiles plus longues, portées sur un long petiole ayant l'aspect d'une tige de *scirpus*, et renferment plusieurs faisceaux vasculaires (3?), devenant libres par le desséchement du tissu cellulaire que ce pétiole renferme à l'état vivant; segments fertiles linéaires, flexueux.

Mexique, vallée d'Orizaba, Cerro del agua, à 2,700 mèters d' altitude. (W. Schaffner, no. 98; 1854.)

Dimensions: frondes stériles, 46 centim. sur 8–9 centim. d'envergure; segments, 8 millim. a la base; frondes fertiles, 65–70 centim.; le pétiole est à la lame :: 2 : 1.—FÈE.

This description is so defective that the best treatment it could receive has been reduction to *P. semicordata;* moreover, it is understood that the type specimen has been effectively lost for many years. When, however, the attempt is made to discriminate the species hitherto merged in *L. semicordata,* it becomes expedient, if possible, to identify this one. There are specimens in the United States National Herbarium that conform to Fée's specifications, unless it be as to the bundles in the stipe, and I am assigning his name to them. Such are: *Charles L. Smith 2063,* from the Sierra de Clavellinas, Oaxaca, altitude 9,000 feet; *Rose and Painter 7598,* near Etzatlan, Jalisco; and *Pringle 8958,* from the state of Puebla. These seem to be rather small forms of a fern better exemplified by *Pringle 4999,* which I regarded as a new species, before seeing the others. Its description is given, without a new name, to supplement or substitute Fée's.

Fronde sterile 75 cm alta, 15 cm lata, ad basin pinnata, utrinque angustata, herbacea, utraque facie viride; costa straminea, applanato-quadrangulata; pinnis infimis 2–3 cm longis, adnatis, subfalcatis, remotis; sequentibus 10- ad 15-paribus sensim accrescentibus 4–5 mm latis, spatie 15 mm lato separatis, ala angusta sursumcurrente confluentibus; medialibus 8 cm longis, 7 mm latis, rectis, spatio aequilato separatis, sensim acuminatis, apices versus argute irregulariter biserratis, alibi serrulatis; supremis coadunatis in apicem acuminatam frondis mergentibus frondis fertilis stipite ultra 50 cm longo, valido, rufo-stramineo; fronde 80 cm alta, 10 cm lata, pinnata; pinnis infimis abbreviatis valde remotis (4–5 cm inter se distantibus), subsessilibus; medialibus usque ad 7 cm longis, 3–4 mm latis, venulis incrassatis fructiferis liberis.

Mexico, Oaxaca, by brooks, Sierra de Clavellinas, altitude 2,700 m. s. m., *C. G. Pringle 4999.* Distributed as *Lomaria attenuata* Willdenow.

The sporangia are one-third millimeter or more long, on pedicels longer than the sporangia, of about five rows of cells, slender for the genus; annulus of about twenty thickened cells and about ten thinner ones at the stomium; spores tetrahedral, minutely roughened.

This is clearly a relative of *P. semicordata* (Presl) Christ, as most positively shown by the margin of the sterile frond, but is larger, more slender throughout, and especially distinguished in appearance by the long drawn out lower part of the frond.

Both *Lomaria attenuata* Willdenow and *L. meridense* Klotzsch are real *Lomaria,* or *Blechnum.*

25. PLAGIOGYRIA SEMICORDATA (Presl) Christ.

Plagiogyria semicordata (Presl) CHRIST, Farnkräuter (1897) 176.
Lomaridium ? semicordatum PRESL, Epim. Bot. (1849) 155.

Fronde fertili oblongo-lanceolata glaberrima pinnata, pinnis patentissimis linearibus obtusis basi inferiore cordatis superiore adnatis, fasciculo vasorum stipitis hippocrepico, sporangiis in seriebus semiannularibus discretis.

Habitat in sylvis Columbiae (inventor ignotus).—PRESL.

As Presl had neither caudex nor sterile frond, and the fertile frond is poor material for specific identification, I omit his further description.

Plagiogyria biserrata METTENIUS, Plagiogyria (1858) 272.

Truncus obliquus diametri 1″; folia chartacea rigida flavo-viridia glabra, difformia, sterilium petiolus 1–4″ longus, stramineus, anguste alatus, lamina 1–1½′ longa, lanceolata vel lato-lanceolata, acuminata, pinnatisecta, apice pinnatifida; segmenta numerosa, e medio utrinque decrescentia, media 1½–2½″ longa, 4–5‴ lata, patentia vel patenti-divergentia subfalcata basi sursum paullulum dilatata adnata et ala angusta herbacea vel callosa coadunata, oblongo- vel elongato-oblongo-lanceolata, acuminata, inaequaliter vel duplicato-argute serrulata, superiora approximata, inferiora subdistantia, basi inferiore soluta, decrescentia; nervi secundarii manifesti, ½‴ distantes, sub angulo 60° decurrentes, indivisi vel furcati, dentes intrantes; foliorum fertilium petiolus 2–3″ longus; lamina 1¼–2′ longa, elongato-lanceolata; segmenta subdistantia, oblique patentia, 1–3″ longa, 2–2½‴ lata, basi sursum dilatata adnata et ala angustissima sulcis lateralibus petioli abscondita, coadunata, linearia, obtusa, margine attenuato subscarioso subrevoluto dilacerata; nervi secundarii 1–1½‴ distantes, indivisi vel furcati, liberi, parte superiore incrassati; sori nervorum partem incrassatam occupantes vix vel paullulum in parenchyma nervis interjectum producti, denique confluentes, et totam paginam inferiorem, costa excepta, occultantes, margine revoluto vix velati.

Columbia, Col. Tovar (Moritz 400). Merida (Linden 556). Mexico (Karwinsky).—METTENIUS.

In technical systematic botany this is the type of the genus; and the first specimen cited is the type of the species, as *P. biserrata.* However, the reduction of *P. biserrata* to *P. semicordata* is generally accepted, and Presl's defective specimen thus becomes the specific type.

Lomaria pectinata Liebmann, cited as a synonym of this species, requires especial attention, because if identifiable as such, it probably has priority. The description is of a sterile frond, "so characteristic that one cannot do other than recognize a *Lomaria* in it," which might, indeed be a *Plagiogyria,* though its segments are notably narrow. It was said to grow on oak trunks—"Voxer paa Egestammer"—but this was probably a mistake, for the genus is very strictly terrestrial. Doctor Christensen was kind enough to send me the type specimen for inspection. It is a small, sterile frond; positively enough a *Plagiogyria,* but not referable to any species in our present state of knowledge of the juvenile stages of the American species. It is not at present worth while to transfer the name. Plate 15 is a photograph of Liebmann's type.

Plagiogyria ? aequidentata Fournier may be dismissed in the same way. Only a sterile frond was ever seen. It had crenate leaflets, and very probably belonged in some other genus.

26. PLAGIOGYRIA ANISODONTA Copeland sp. nov. Plate 9.

Stipitibus validis, fulvis vel fuscis, sursum rhachibusque obtuse quadrangulatis; fronde sterile ca. 80 cm alta, ultra 25 cm lata, deorsum haud angustata, in apicem lanceolatam 4.5 cm longam leviter pinnatifidam abrupte angustata, papyracea, laete virde; pinnis inferioribus 2–4 cm remotis liberis et medialibus anguste confluentibus spatio 5–8 mm lato separatis usque ad 15 cm longis, 12 mm latis, subhorizontalibus, sensim acuminatis, versus rhachin serrulatis, apices versus grosse et irregulariter inciso-serratis, costa utraque facie prominente, inferne biangulato-applanata, fulva; venis distantibus, plerumque ad costam geminatis et infra mediam laminam saepe furcatis, angulo ca. 60° cum costa et margine in dentes intrantibus; fronde fertile 60–75 cm alta, abrupte caudata, deorsum vix angustata; pinnis infimis remotioribus (4 cm remotis) adnatis, medialibus et superioribus ad rhachin abrupte utrinque dilatatis, superioribus ala angusta sterile connexis, medialibus et inferioribus usque ad 12 cm longis, 3–4 mm latis.

Costa Rica, extinct crater of Mount Poas, altitude 2,800 m. s. m., *O. Jimenes 1018*, 1915. Type in the United States National Herbarium, three sheets, Nos. 865089, 865090, and 865091; also, ibidem, *Standley 34895*, and *Conduz 10714* (both of these smaller than the type, but still large ferns).

In the distal half of each pinna, the product of the forking of each main vein or pair of geminate veins affects the margin as a unit, feeding into an obscure and shallow lobe or crenation, which in turn is very sharply toothed. Nine or ten veinlet-tips, each in its tooth, occupy a centimeter of margin. The annulus is oblique and often crooked, passing clear of the pedicel, with about twenty-one thickened cells. It is distinctly wider than in the two species to follow, and more oblique. The spores are tetrahedral, or sometimes 4-lobed, and very minutely roughened.

Hardly separable from this, although distinct in appearance, are Costa Rica specimens with simply forked veins and correspondingly uniform margin. They are usually smaller, and may be regarded as imperfectly developed; they agree perfectly in microscopic characters. Such are: *Pittier 2920*, from Poas; *Pittier 10498*, from Cerro de las Vueltas, altitude 3,000 meters; another specimen of Conduz, probably misnumbered 11261; and at least a part of the sterile specimens distributed by Christ from Werkle's collection, without number.

27. PLAGIOGYRIA MAXONI Copeland sp. nov. Plate 10.

Caudice adscendente; stipitubus frondis sterilis 12–20 cm, fertilis ca. 30 cm altis, deorsum et basibus dilatatis nigrocastaneis, sursum rhachibusque stramineo-viridibus, obtuse applanato-quadrangularibus; fronde sterile 50 cm alta, ca. 18 cm lata, deorsum vix vel paullo angustata, sursum subabrupte in caudam parvam lobatam contracta, papyracea; pinnis infimis ca. 6-paribus suboppositis liberis basi basiscopice exaratis, acroscopice anguste sursumcurrentibus, medialibus ala angustissima connexis, basibus fere aequilateralibus, maximis 10 cm longis, 9 mm latis, acuminatis, rhachin versus obscure, apices versus argute et grosse irregulariter serratis cum lobis obscuris saepius tridentatis; venis patentibus, prope rhachin furcatis, media longitudine saepe bis furcatis, ad marginem versus apicem segmenti curvatis; fronde fertile usque ad 40 cm alta, ca. 10 cm lata, deorsum moderatim angustata, caudata; pinnis medialibus 6 cm longis, 4 mm latis, plerisque basi basiscopice rotundatis, acroscopice adnatis, solummodo supremis dilatatis.

Jamaica, summit of Blue Mountain Peak, altitude 2,100 to 2,200 m. s. m., *Maxon 9910,* 1926. Type in United States National Herbarium No. 1302136; also, Mossman's Peak, *Maxon 9721. Maxon 1439,* 1903, from Blue Mountain Peak, is a stunted specimen.

Distinguished by the slender segments, the lower ones somewhat narrowed toward the rachis. About ten teeth occupy one centimeter of the margin. The annulus has twenty to twenty-two thickened cells, and is decidedly oblique. As the sporangium matures, in this and in other species, these cells are the first to thicken and discolor; then the two to four cells beside the stomium thicken, while still isolated, the more feeble differentiation of the cells between these and the ends of the elastic ring being the last step. The stomium cells are less widened in this species than in any other examined. The spores have three almost flat faces, the fourth remaining strongly convex; they are densely tuberculate.

28. PLAGIOGYRIA LATIFOLIA Copeland sp. nov. Plate 11.

Stipite frondis sterilis 45 cm, frondis fertilis 50 cm altis, fulvis, gracilibus; fronde sterile 70 cm alta, 25 cm lata, deorsum vix angustata, sursum ad segmentum terminale lanceolatum 4–5 cm longum acuminatum pinnatifidum sensim angustata, papyracea; pinnis inferioribus liberis vix remotis, inframedialibus subhorizontalibus ca. 13 cm longis, ca. 11 mm latis, ala fere obsoleta connexis, spatio ca. 6 mm lato separatis, valde acuminatis, prope rhachin denticulato-serrulatis, alibi argute lobulato-serratis; venis saepe bis furcatis; fronde fertile 40 cm alta, caudata, deorsum paullulum angustata; pinnis fere omnibus liberis, patentibus, medialibus 8 cm longis, 3–4 mm latis, basi acroscopice paullulum dilatatis.

Peru; Cani (a pueblo 7 miles northeast of Mito), altitude ca. 2,550 m. s. m., *J. Francis McBride 3432,* 1923. Type in the United States National Herbarium, two sheets, No. 1193294, sterile frond, and No. 1193293, fertile and immature sterile fronds.

The margin responds to the character of the venation by forming obscure lobes or crenations, each receiving all the forks of a main vein, and bearing as many teeth as a main vein has branches (geminate veins acting as one in this relation). The teeth are sharp and deep; and, because the veins are widely divergent from the costa, not exceedingly unequal-sided. Thirteen to fifteen veinlets run to each centimeter of margin. The

annulus, with eighteen to twenty thickened cells and a dozen flattened ones, is only moderately oblique, somewhat sinuous or irregular, and slender. The thickened cells hardly pass beyond the side of the pedicel, so that the stomium opens low on the side of the sporangium. The spores are tetrahedral and minutely tuberculate.

29. PLAGIOGYRIA DENTICULATA Copeland sp. nov. Plate 12.

Stipite trigono et rhachi tetragona superne late sulcata fulvis vel ferrugineo-fulvis; fronde sterile 60 cm alta, medio 15–18 cm lata, deorsum modo angustata, sursum sensim ad apicem acutam contracta, tenuiter coriacea; pinnis infimis liberis, vix 2 cm remotis, medialibus et superioribus basi confluentibus, sinu anguste rotundato vix 0.5 mm a rhachi remoto et usque ad apicem frondis vix remotiore; segmentis medialibus fere horizontalibus, 8–9 cm longis, 7–8 mm latis, medio longitudine ipsorum ca. 3 mm inter se remotis, potius acutis quam acuminatis, minute denticulatis, costis praecipue inferne prominentibus, plus minus ferrugineo-tinctis; venis saepe bis furcatis, in margine hyalinis, angulo subrecto in dentes intrantibus, dentibus ita subaequilateralibus; fronde fertile modo minore, 45 cm alta; pinnis remotioribus fere omnibus liberis, medialibus 6–8 cm longis, supra basin 4 mm latis, basi acroscopice dilatatis, basiscopice interdum exaratis.

Bolivia, leg. Th. Herzog "im Nebelwald des Bergkammes der Laguna verde bei Comarapa. 2600 m. April 1911. No. 1954." Type in the United States National Herbarium No. 1191649. Also, leg. Buchtien, 1908, Nord-Yungas, altitude 3,300 meters. Also, probably, Peru, Yanano, altitude 1,800 meters, *McBride 3830*, 1923.

The venation is very fine and close, consequent on the double forking of many veins, each branch of which enters a minute tooth, these standing about twenty to a centimeter of margin. The wide angle at which the veinlets strike the margin results in almost equal-sided teeth, so that the margin is denticulate, instead of serrate, as are most species. The annulus is slender, for *Plagiogyria*, with eighteen to twenty thickened cells, just oblique enough to pass the pedicel. The spores are tetrahedral or somewhat 4-lobed, and minutely tuberculate.

The specimen cited from Peru has a more serrulate margin and wider fertile pinnæ.

This is nearly related to the preceding species, and the two constitute a reasonably distinct group, characterized by the very ample fronds and congested venation. The margin of the sterile frond distinguishes clearly between the two.

30. PLAGIOGYRIA OBTUSA Copeland sp. nov. Plate 13.

Rhizomate adscendente; stipite frondis sterilis ca. 8 cm alto, frondis fertilis duplo altiore, sursum rhachique superne sulcatis, quadrangularibus; fronde sterile 20–25 cm alta, 5 cm lata, tenuiter sed rigide chartacea; pinnis infimis 1 cm longis deflexis, sursumcurrentibus, liberis vix remotis; segmentis medialibus horizontalibus, spatio 3 mm lato separatis, sinu obliquo, supramedialibus maximis, 25 mm longis, 6 mm latis, plerisque obtusis, apices versus argute alibi obscure serrulatis, costis et apicibus venularum ferrugineis, venis simplicibus vel saepius furcatis, proximis; fronde fertile 15–20 cm alta, 3 cm lata, pinnis infimis 15–20 mm remotis 8 mm longis, maximis supramedialibus 16 mm longis, 2–3 mm latis, apud rhachin inconspicue dilatatis.

Cuba, near Pico Turquino, *Leon 11126*, 1922. Type in United States National Herbarium No. 1049927.

Clearly distinguished by small size, narrowly oblanceolate fronds, and rigidity. About twenty veinlets reach each centimeter of margin, at such an angle that the minute teeth are very oblique. The annulus is oblique enough to pass clear of the pedicel and the adjacent cells; about twenty cells are thickened. The spores are minutely but densely tuberculate.

31. PLAGIOGYRIA URBANI (Brause) Copeland comb. nov. Plate 14.

Blechnum urbani BRAUSE, in Urban, Symb. Antil. 7 (1911) 158.

Lomaria; rhizomate erecto, cr. 6 cm. longo, cr. 6 mm. crasso, folia fasciculata emittente; foliis sterilibus fertilibusque inaequalibus, petiolatis; petiolis crassis (basi cr. 4 mm.), melleis, basi fuscescentibus, supra canaliculatis, infra teretibus, usque ad basin undulato-alatis, fertilibus cr. 25 cm., sterilibus cr. 7 cm. longis, basi dense, ceterum sparse paleis ferrugineis integris mox deciduis obtectis; rachibus supra canaliculatis, glabris, infra sulcatis, sparse paleis ferrugineis mox deciduis intructis, crassis; laminis sterilibus cr. 23 cm. longis, 7 cm. latis, ambitu lanceolatis, ad basin versus angustatis, in apicem pinnatifidum desinentibus, pinnatis, coriaceis, supra et infra glabris; pinnis cr. 25–30-jugis, approximatis sinu rotundato conjunctis, alternis, horizontaliter patentibus, basalibus angustatis refractis, e basi lata sessili lineari-lanceolatis in apicem serrulatum acuminatis, maximis 4 cm. longis, 6 mm. latis, serratis vel biserratis, infra glandulosis; costis supra glabris, infra paleis mox deciduis vestitis; venis lateralibus

obliquis, infra prominulis, simplicibus vel furcatis, usque ad 2 mm. inter se distantibus; laminis fertilibus cr. 26 cm. longis, ambitu lanceolatis, basi non angustatis, pinnatis; pinnis cr. 26–jugis, sessilibus, remotis, patentibus, ejusdem lateris cr. 1 cm. distantibus, ala angusta connexis, linearibus, maximis cr. 6 cm. longis, 2 mm. latis, marginibus involutis.

Hab. in Sto. Domingo prope Constanza in Valle nuevo 2200 m. alt. in pineto, m. Jun. 1910: H. von Türckheim n. 3408.

Diese Art fällt zunächst durch einige Absonderlichkeiten im Habitus auf . . . . Ferner findet man kaum wieder eine *Lomaria*-Art, welche so scharf und ungleichmässig gesägt ist wie diese hier . . . . Ueber die Schuppen konnte nicht viel gesagt werden, da an der Basis nur wenige verschrumpelte Reste, an der Rachis und der Costa nur wenige Spuren vorhanden waren.—BRAUSE.

This illustrates the familiar fact that one has only to place a plant in the wrong genus and it will quite certainly appear a very distinct novelty. The annulus is more oblique than is usual in *Plagiogyria*, being clear of contact with the insertion of the pedicel. There are about twenty-four typically thickened annular cells, and about twelve flattened cells, the stomium opening far up on the side of the sporangium. The spores are tetrahedral. The material at hand is a photograph of the type and some fragments, United States National Herbarium No. 1146952, showing no trace of the imputed paleæ; but, having been deceived in the same way with other species, I feel sure that the microscope would have shown that these were not peleæ, and were without cellular structure. They are dried-up flakes, remnants of the gelatinous cover of very young fronds.

The margin of the sterile pinnæ, described as remarkably serrate for a *Lomaria*, is remarkable in the opposite respect, for an American *Plagiogyria*. In its proper group, this can be recognized as a species by the relative entireness of these pinnæ (or rather, segments, for all but the lowest are connected by a wing), and by their long and gradual, not at all abrupt, attenuation. For half of their length, they are subentire; in the distal half, they are serrate, with very broad teeth, less than half a millimeter high. The shape of these teeth is a function of the very oblique direction of the veins.

32. PLAGIOGYRIA COSTARICENSIS Mettenius.

Plagiogyria costaricensis Mettenius: KUHN, Linnaea 36 (1869) 149.

Truncus deest; folia sterilia siccitate opaco viridia; lamina ultra 1′ longa, oblonga, basi abruptim attenuata, pinnatisecta; segmenta basi utraque aequaliter dilatata vel superiore latiore adnata, 3½″ longa, 5‴ lata, elongato-oblonga, subfalcata, apice attenuato, obtusa vel obtusiuscula, pleraque

contigua et ala angustissima confluentia, inferiora paullulum decrescentia, distincta, infima vel juga 2–3 infimorum distantia, transversa, abortiva; omnia margine revoluto attenuato subintegerrima; nervi laxi furcati vel more *Doodyae* anastomosantes, apice subincrassata supra sub foveola minuta desinentes; foliorum fertilium petiolus 11″ longus, rhachis straminea, tetragona, 1½′ longa, lanceolata, acuminata, basi brevius attenuata, pinnatisecta; segmenta laxe disposita, ultra 3″ longa, 2‴ lata distincta patentia, sursum adscendente adnata, deorsum soluta, linearia apice attenuato obtusiuscula, margine scarioso, attenuato, integerrima inferiora paullulum decrescentia, remota, utrinque soluta, infima 1¾″ longa; nervi distantes, furcati, apice incrassati, liberi, versus apicem et apice ipso sporangiis onusta porro ad basin marginis hyalini receptaculo lineari, sporangiis occupato, nervis destituto instructa.

Costa Rica, Vulcan de Barba (Wendland 1066).

A *Pl. biserrata* Mett., cui proxima, foliis integerrimis diversa.—KUHN.

242249—4

ILLUSTRATIONS

[Photographs by C. G. Matthews.]

PLATE 1. *Plagiogyria grandis* Copeland; type.
2. *Plagiogyria intermedia* Copeland; type.
3. *Plagiogyria minuta* Copeland; type.
4. *Plagiogyria clemensiae* Copeland; type.
5. *Plogiogyria henryi* Christ; *Henry 13475.*
6. *Plagiogyria petelotii* Copeland; part of the type.
7. *Plagiogyria tenuifolia* Copeland; type.
8. *Plagiogyria arguta* (Fée) Copeland; *Pringle 4999.*
9. *Plagiogyria anisodonta* Copeland; above, cotype; below, fertile frond of type.
10. *Plagiogyria maxoni* Copeland; type.
11. *Plagiogyria latifolia* Copeland; type.
12. *Plagiogyria denticulata* Copeland; type.
13. *Plagiogyria obtusa* Copeland; type.
14. *Plagiogyria urbani* (Brause) Copeland; type.
15. *Lomaria pectinata* Liebmann; type.

PLATE 1. PLAGIOGYRIA GRANDIS COPELAND; TYPE.

PLATE 2. PLAGIOGYRIA INTERMEDIA COPELAND; TYPE.

PLATE 3. PLAGIOGYRIA MINUTA COPELAND; TYPE.

PLATE 4. PLAGIOGYRIA CLEMENSIAE COPELAND; TYPE.

PLATE 5. PLAGIOGYRIA HENRYI CHRIST; HENRY 13475.

PLATE 6. PLAGIOGYRIA PETELOTII COPELAND; PART OF THE TYPE.

PLATE 7. PLAGIOGYRIA TENUIFOLIA COPELAND; TYPE.

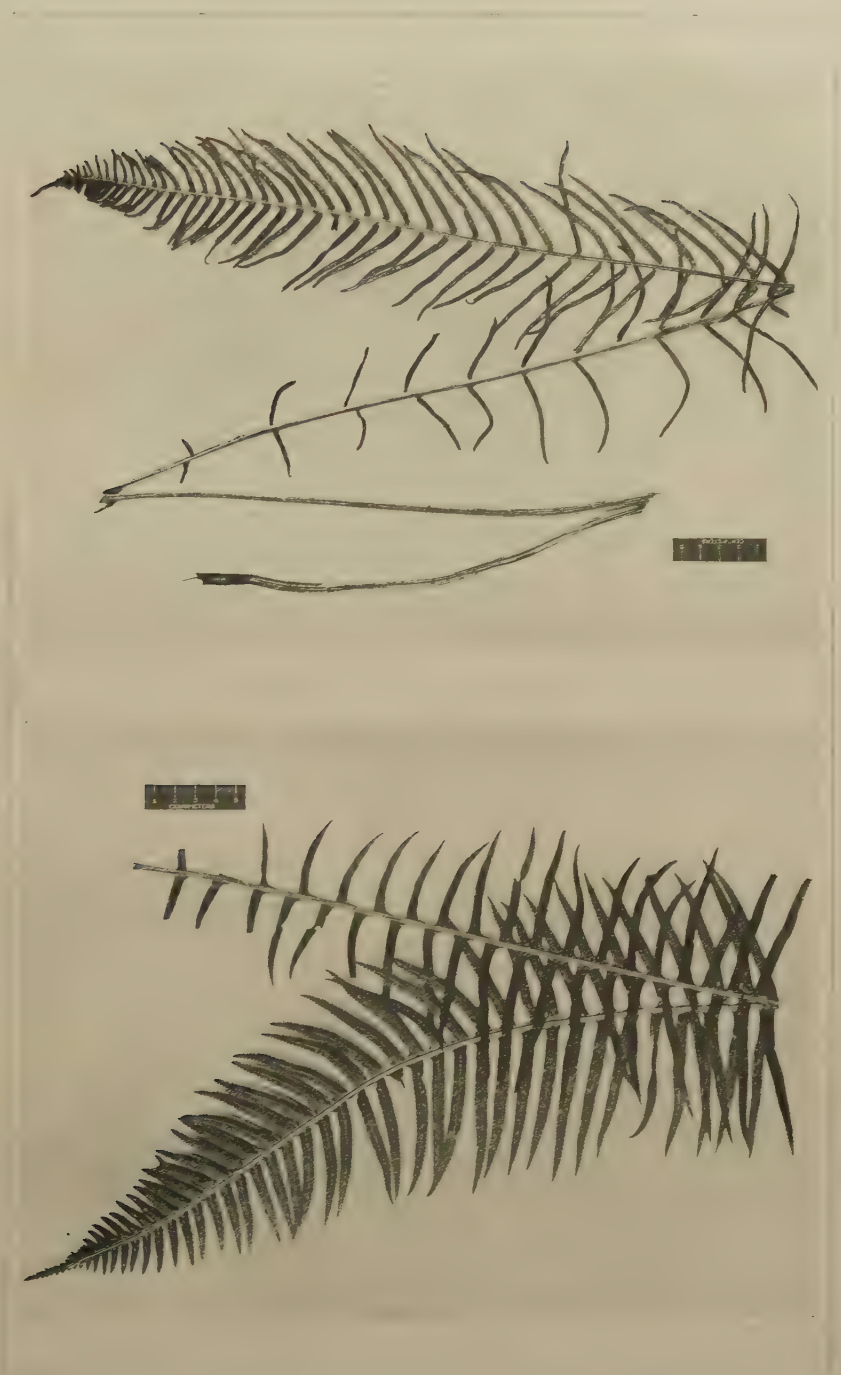

PLATE 8. PLAGIOGYRIA ARGUTA (FÉE) COPELAND; PRINGLE 4999.

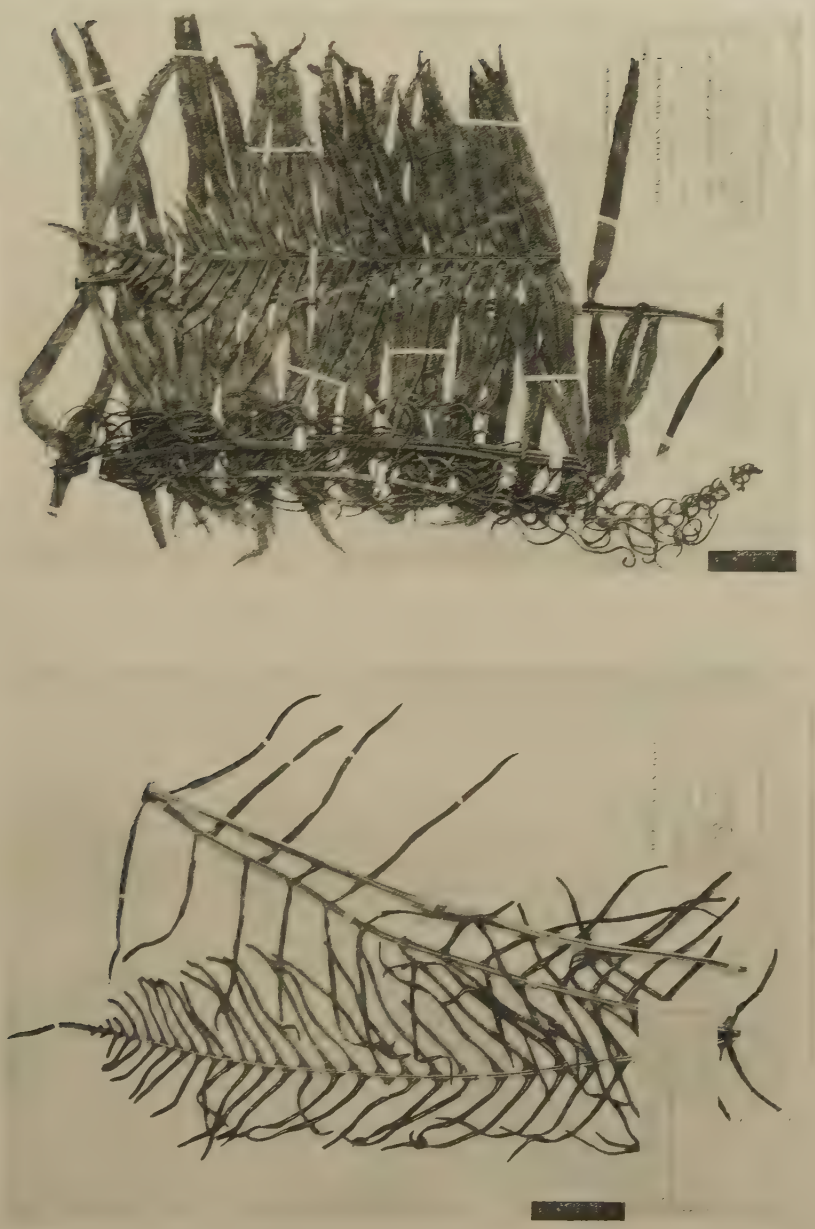

PLATE 9. PLAGIOGYRIA ANISODONTA COPELAND; ABOVE, COTYPE; BELOW, FERTILE FROND OF TYPE.

PLATE 10. PLAGIOGYRIA MAXONI COPELAND; TYPE.

PLATE 11. PLAGIOGYRIA LATIFOLIA COPELAND; TYPE.

PLATE 12. PLAGIOGYRIA DENTICULATA COPELAND; TYPE.

PLATE 13. PLAGIOGYRIA OBTUSA COPELAND; TYPE.

PLATE 14. PLAGIOGYRIA URBANI (BRAUSE) COPELAND; TYPE.

PLATE 15. LOMARIA PECTINATA LIEBMANN; TYPE.

MARINE DIATOMS FROM DAIREN, SOUTH MANCHURIA

By B. W. Skvortzow

Of Harbin, China

TWO PLATES

The diatoms living in the Yellow Sea and the Eastern Sea of China are relatively very little known. One enumeration of forms observed in samples from the environs of Ningpo and Nimrod Sound was published by P. Petit.[1] We find a small note, Grundroben aus den chinesischen Gewässern, gesammelt von Rudolf Rabenhorst fil. analysirt von Dr. Schwarz in Berlin, with description of a new *Triceratium*.[2] Some information about diatoms is also found in papers and monographs by A. Schmidt, P. T. Cleve, and A. Grunow. Three years ago N. Gist Gee[3] published an interesting list of diatoms from Soochow and Ningpo.[3]

So far as I know, there is no published list of diatoms from the northern part of the Yellow Sea or from Liaotung, and such a list I am giving in the present note.

In 1926, I received from my young friend A. Prosowetsky a small collection of sea mud, from oysters collected at Dairen. This mud was sufficiently rich in diatoms, and the present paper lists seventy-one species and varieties in twenty-one genera, including three new species and twelve new varieties and forms.

ACTINOPTYCHRUS UNDULATUS (Ehrenb.) Ralfs.

A. Schmidt, Atlas Diatom. pl. 1, figs. 1–6.

Diameter, 0.0255 mm; puncta, 16 to 18 in 0.01 mm.

COSCINODISCUS LINEATUS Ehrenb.

A. Schmidt, Atlas Diatom. pl. 59, figs. 27–30, 31, 32; pl. 114, fig. 13.

Frustule diameter, 0.0697 mm. Markings hexagonal, 2.5 in 0.01 mm, somewhat smaller towards the periphery. Border

[1] Memoires de la Sc. Nat. de Cherburg 23 (1881) 251–256.
[2] Hedwigia (1874) No. 11.
[3] Lingnaan Agr. Rev. 3 (1925) 151–155.

narrow, distinct. Geographic distribution: Kamtchatka Sea, Indian Ocean, Japan, California.

COSCINODISCUS RADIATUS Ehrenb.

Ehrenberg, Mikrogeologie pl. 19, fig. 1; A Schmidt, Atlas Diatom. pl. 60, figs. 5, 6, 9.

Diameter, 0.17 mm; markings, 2.5 to 3.5 in 0.01 mm. Geographic distribution: Caspian, North, Baltic, and China Seas, Atlantic Ocean, Japan.

COSCINODISCUS LENTIGINOSUS Janisch.

A. Schmidt, Atlas Diatom. pl. 58, fig. 11.

Diameter, 0.0724 mm. Markings round, granular, 8 in 0.01 mm. Geographic distribution: Patagonia, Antarctic Ocean, Oamaru deposit.

HYALODISCUS SUBTILIS Bailey var. JAPONICA Castracane.

Castracane, Report on the Diatomaceae collected by H. M. S. Challenger 1873–1876 p. 140. pl. 18, fig. 4. (Coast of the Japan Sea.)

Our specimens are 0.0544 mm in diameter.

BIDDULPHIA AURITA Bréb. var. ORIENTALIS Mereschkowsky.

C. Mereschkowsky, On Polynesian Diatoms, Scripta Bot. (1900–1902) 119, pl. 18; A. Schmidt, Atlas Diatom. pl. 120, figs. 5–8.

Length, 0.0306 mm; breadth, 0.0153; striæ, 12 in 0.01 mm.

BIDDULPHIA PULCHELLA Gray.

Length, 0.0935 mm; breadth, 0.0765; striæ, 4 in 0.01 mm. Common.

TRICERATIUM FAVUS Ehrenb. Plate 2, fig. 14.

A. Schmidt, Atlas Diatom. pl. 82, figs. 13, 14.

Diameter of the frustule, 0.1115 mm.

MELOSIRA SULCATA (Ehr.) Kütz. f. RADIATA Grun.

A. Schmidt, Atlas Diatom. pl. 176, fig. 22.

Diameter, 0.0221 mm; striæ, 15 in 0.01 mm.

MELOSIRA ARCHITECTURALIS Brun.

A. Schmidt, Atlas Diatom. pl. 177, fig. 48.

Length, 0.0069 mm; breadth, 0.017. Geographic distribution: Oamaru, Bains Tower.—*Brun and Gründler.*

CYCLOTELLA STRIATA (Kg.) Grun.

Diameter of the valve, 0.034 mm; striæ, 11 to 12 in 0.01 mm. Geographic distribution: Pacific Ocean, Japan Sea.

LICMOPHORA GRATIS Ehrenb. Plate 1, fig. 1.

Length, 0.0969 mm; breadth, 0.0119; striæ, 20 in 0.01 mm. Geographic distribution: Atlantic Ocean, Adriatic Sea.

GRAMMATOPHORA MARINA (Lynb.) Kütz.

Geographic distribution: Mediterranean Sea, Atlantic and Pacific Oceans, Japan Sea.

GRAMMATOPHORA JAPONICA Grun.

Length, 0.0578 mm; breadth, 0.0187; striæ, 18 to 20 in 0.01 mm.

CAMPYLODISCUS INTERMEDIUS Grun. Plate 1, fig. 2.

Length, 0.073 to 0.102 mm; breadth, 0.0697; striæ, 4 in 0.01 mm. Geographic distribution: South China Sea.

CAMPYLODISCUS SAMOENSIS Grun. Plate 1, fig. 6.

Length, 0.102 mm; breadth, 0.093; striæ, 3 to 4 in 0.01 mm. Geographic distribution: Mediteranean Sea, Pacific Ocean, South China Sea.

SURIRELLA LIAOTUNGIENSIS sp. nov. Plate 1, fig. 11.

Valve elliptic broad with rounded ends; length, 0.0306 mm; breadth, 0.0238. Rim broad and massive, marked with strong, closely set lines, without a median line.

SURIRELLA LIAOTUNGIENSIS var. MINUTA var. nov. Plate 1, fig. 12.

Valve small elliptic bisected with a line; length, 0.0187 to 0.0221 mm; breadth, 0.012 to 0.0153.

SURIRELLA FLUMINENSIS Grun. Plate 1, fig. 3.

Length, 0.0425 mm; breadth, 0.0305. Mediterranean Sea.

SURIRELLA FASTUOSA Ehrenb. Plate 1, fig. 7.

Length, 0.0629 mm; breadth, 0.0442.

SURIRELLA FASTUOSA Ehrenb. var. CUNEATA A. Sm. Plate 1, figs. 4, 5.

Length, 0.0578 to 0.0646 mm; breadth, 0.0323 to 0.0442; striæ, 2 to 3 in 0.01 mm.

SURIRELLA GEMMA Ehrenb. Plate 1, fig. 13.

Length, 0.0629 to 0.0935 mm; breadth, 0.034 to 0.04; striæ, 2 to 3 in 0.01 mm.

COCCONEIS SCUTELLUM Ehrenb. var. JAPONICA var. nov. Plate 1, fig. 8.

Cocconeis japonica A. SCHMIDT, Atlas Diatom. pl. 190, fig. 30, from Yokohama.

Length, 0.0272 mm; breadth, 0.0152. Valve with narrow axial area. Loculi large, arranged in longitudinal and transverse rows.

COCCONEIS SCUTELLUM Ehrenb. var. PARVA Grun.

Length, 0.017 mm; breadth, 0.0192. Geographic distribution: East Cape, Baltic and Adriatic Seas.

COCCONEIS SCUTELLUM Ehrenb. var. ORNATA Grun. Plate 1, fig. 9.

Length, 0.0459 mm; breadth, 0.0357; striæ, 5 in 0.01 mm. Geographic distribution: Kamtschatka and North Pacific Ocean.

COCCONEIS PSEUDOMARGINATA Greg. var. FORMOSA var. nov. Plate 1, figs. 14 and 15.

Valve elliptical; length, 0.029 to 0.0459 mm; breadth, 0.0204 to 0.032. Upper valve with narrow lanceolate axial area and narrow lunate lateral areas. Striæ between the areas, 18 to 22 in 0.01 mm. Lower valve with straight median line ending at some distance from the margin. Axial area narrow, central small. Typical *C. pseudomarginata* Greg. is found in Greenland, Spitsbergen, Kara, North, Mediterranean, and Red Seas, Madagascar, China, Sandwich Islands, and fossil in Hungary.

MASTOGLOIA FIMBRIATA Btw.

Length, 0.068 mm; breadth, 0.047. Geographic distribution: Mediterranean and Adriatic Seas, Mauritius, Madagascar, Japan, China, Australia, Oceania, Honduras, Brazil.

DIPLONEIS AESTIVA Donk. forma β. Plate 1, fig. 10.

Length, 0.0255 mm; breadth, 0.021; striæ, 12 or 13 in 0.01 mm. Geographic distribution: Sweden, Sumatra.

DIPLONEIS LINEATA Donk. Plate 1, fig. 17.

Length, 0.0459 mm; breadth, 0.017; striæ, 9 or 10 in 0.01 mm. Geographic distribution: North, Mediterranean, and Adriatic Seas.

DIPLONEIS SMITHII Bréb.

Length, 0.0544 to 0.0612 mm; breadth, 0.029 to 0.0306; striæ, 5.5 to 6.5 in 0.01 mm. Our form is identical with Peragalli's figure.[4] Geographic distribution: North, Baltic, and Mediterranean Seas, Madagascar, Java, New Zealand, Campeachy Bay.

DIPLONEIS CHERSONENSIS Grun. Plate 1, fig. 18.

Length, 0.068 to 0.0884 mm; breadth, in the middle part, 0.012 to 0.0153; in the ends, 0.0238 to 0.0289; striæ, 9 to 14 in 0.01 mm. Geographic distribution: North and Mediterranean Seas, Ceylon, Philippines, China, Tahiti, West Indies.

[4] Diatom. de France pl. 19, fig. 29.

NAVICULA LIBER W. Sm. var. LINEARIS Grun. f. ORIENTALIS f. nov. Plate 1, fig. 21.

Length, 0.0748 mm; breadth, 0.0085; striæ, 11 in 0.01 mm. The typical form of *Navicula liber* var. *linearis* Grun. has 20 to 29 striæ in 0.01 mm and is found on the Atlantic coasts of Europe, Africa, and America; and in Ceylon, Honduras, and the Gulf of Mexico.

NAVICULA LIBER W. Sm. var. ELONGATA Grun. Plate 1, fig. 22.

A. Schmidt, Atlas Diatom. pl. 50, fig. 29.

Length, 0.0578 to 0.0748 mm; breadth, 0.0085 to 0.0102; striæ, 15 to 18 in 0.01 mm. Geographic distribution: North, Mediterranean, and Red Seas, Aylon, Florida.

NAVICULA LIBER W. Sm. var. GENUINA Cleve. Plate 1, fig. 19.

Length, 0.0884 mm; breadth, 0.0119 in the middle, 0.0187 in the ends; striæ, 18 to 20 in 0.01 mm.

NAVICULA LIBER f. SINICA f. nov. Plate 1, fig. 23.

Valve linear with convex margins and obtuse ends. Length, 0.119 mm; breadth, 0.0153. Axial area narrow, central area small. Striæ, 17 or 18 in 0.01 mm. This form is akin to *Navicula liber* var. *genuina* Cleve, between fig. 20 and fig. 37 of Schmidt's pl. 50, Atlas der Diatomaceen-Kunde.

NAVICULA HALOPHILA Grun. var. BREVIS var. nov. Plate 1, fig. 24.

Valves rhombic-lanceolate with obtuse ends. Length, 0.0487 mm; breadth, 0.0153; striæ, 18 in 0.01 mm, parallel. *Navicula halophila* is found in Sweden, England, Belgium, and France, in brackish water.

NAVICULA LIAOTUNGIENSIS sp. nov. Plate 1, fig. 26.

Valve narrow lanceolate with acute ends. Length, 0.182 mm; breadth, 0.021. Central nodule dilated to a stauros. Striæ, 14 or 15 in 0.01 mm. Puncta distinct. *Navicula liaotungiensis* is connected with *N. balearica* Cleve, known from the Balearic Islands.

NAVICULA GRANULATA BAIL. Plate 1, fig. 27.

Length, 0.0612 mm; breadth, 0.034; striæ, 8 or 9 in 0.01 mm. Geographic distribution: North Sea, Mediterranean Sea, Ceylon, Japan, Sydney.

NAVICULA CRUCICULA W. Sm. var. ORIENTALIS var. nov. Plate 1, fig. 16.

Valve elliptic with somewhat obtuse ends. Length, 0.0221 mm; breadth, 0.0102. Central nodule transversely dilated. Striæ,

16 or 17 in 0.01 mm. The median stronger and more distant, slightly radiate. Typical *N. crucicula* is found in the North, Baltic, and Adriatic Seas and the Atlantic Ocean.

NAVICULA (SCHIZONEMA) RAMOSISSIMA Ag. Plate 1, fig. 25.

Length, 0.056 mm; breadth, 0.0102; striæ, 10 or 11 in 0.01 mm. Geographic distribution: North Sea, Canada, Caspian Sea.

TRACHYNEIS ASPERA Ehrenb. var. VULGARIS Cleve.

Length, 0.107 mm; breadth, 0.0153; striæ, 8.5 in 0.01 mm. Geographic distribution: Arctic America, North Sea, New Zealand, Samoa, Java, Galapagos Islands.

TRACHYNEIS ASPERA Ehrenb var. ORIENTALIS var. nov. Plate 2, fig. 1.

Valve elliptic-lanceolate with obtuse or subrostrate ends. Length, 0.159 mm; breadth, 0.0255. Alveoli disposed in longitudinal and transverse rows; the former about 8.5 in 0.01 mm. This variety is closely connected with *T. aspera* and *T. johnsoniana.*

STAURONEIS PELLUCIDA Cleve var. ORIENTALIS var. nov. Plate 1, fig. 30.

Valve elliptic with broad, rounded ends. Length, 0.0272 mm; breadth, 0.0119. Central nodule transversely dilated to a stauros. Striæ, 15 in 0.01 mm. This form is connected with *S. pellucida* f. *mediterranea* Cleve, see Synopsis des Diatomees de Belgique, page 145.

PLEUROSYGMA NORMANII Ralfs. Plate 2, fig. 2.

Length, 0.156 mm; breadth, 0.027; striæ, 18 to 20 in 0.01 mm. Geographic distribution: North, Mediterranean, and Red Seas, Spitzbergen, Java, Sumatra, Atlantic Coast of North America.

PLEUROSYGMA FORMOSUM W. Sm. Plate 2, fig. 3.

Length, 0.425 mm; breadth, 0.066; striæ, 10 or 11 in 0.01 mm. Geographic distribution: North, Mediterranean, and Red Seas, Java, China, West Indies.

PLEUROSSYGMA ELONGATUM W. Sm. Plate 2, fig. 4.

Length, 0.153 mm; breadth, 0.0255; striæ, 15 in 0.01 mm. Geographic distribution: North, Mediterranean, Adriatic, Baltic, and Caspian Seas, Atlantic Coast of North America, Java, Sumatra, China.

PLEUROSYGMA BALTICUM Ehrenb. Plate 2, fig. 5.

Length, 0.24 mm; breadth, 0.0306; striæ, 11 or 12 in 0.01 mm. Geographic distribution: Baltic, North, Caspian, Mediterranean, Adriatic, and Red Seas, Java, Sumatra, Sandwich Islands, Samoa, Brazil, West Indies, Atlantic Coast of the United States.

PLEUROSYGMA DIMINUTUM Grun. Plate 2, fig. 6.

Length, 0.1139 mm; breadth, 0.0153; striæ, 18 to 20 in 0.01 mm. Geographic distribution: Adriatic and Mediterranean Seas.

PLEUROSYGMA SPECIOSUM Sm. Plate 2, fig. 7.

Length, 0.306 mm; breadth, 0.0289; striæ, longitudinal, 15; transverse, 15. Geographic distribution: North, Mediterranean, and Red Seas, Java, Sumatra, Labuan, China, Port Jackson, Barbados.

AMPHORA BIGIBBA Grun. Plate 1, fig. 20.

Length, 0.029 mm; breadth, 0.0076. Geographic distribution: Balearic Islands, Adriatic Sea, Japan, Chile, West Indies, Campeachy Bay.

AMPHORA DECUSSATA Grun. Plate 2, fig. 8.

Length, 0.1037 mm; breadth, 0.0187; striæ, 12 to 14 in 0.01 mm. Geographic distribution: Balearic Islands, Adriatic Sea, China, Honduras, Barbados.

AMPHORA RHOMBICA Kitton var. SINICA var. nov. Plate 2, fig. 9.

Valve cymbiform with long curved ends. Length, 0.1363 mm; breadth, 0.0238; striæ, 12 to 14 in 0.01 mm. The typical form *A. rhombica* is found in the Mediterranean Sea, Sumatra, the Philippines, and China.

AMPHORA OHGII sp. nov.[5] Plate 2, fig. 10.

Frustule in outline lunate with slightly rostrate ends. Length, 0.0289 mm; breadth, 0.01; striæ, 16 to 18 in 0.01 mm; punctate. Median line almost straight. Axial area distinct. This new species is remarkable for its lunate frustule. This species seems to me to be nearest akin to *A. minuta* Pant. or *A. szaboi* Pant. found fossil in brackish water in Hungary.

AMPHORA PROTEUS Greg. var. ROBUSTA var. nov.

Frustule somewhat rectangular, about 3.5 times longer than broad, with obtuse ends. Length, 0.0459 mm; breadth, 0.011 mm. Axial area narrow. Striæ, 12 to 13 in 0.01 mm.

AMPHORA PROTEUS Greg. Plate 2, fig. 12.

Length, 0.0289 mm; breadth, 0.006; striæ, 15 in 0.01 mm. Geographic distribution: North, Mediterranean, and Black Seas, China, Galapagos Islands, Campeachy Bay.

[5] Named in honour of Prof. J. Ohga, the well-known Japanese botanist in South Manchuria.

AMPHORA OSTREARIA Bréb. var. TYPICA Cleve. Plate 2, fig. 13.

Length, 0.0646 mm; breadth, 0.0153; striæ, 14 in 0.01 mm. Geographic distribution: Mediterranean and North Seas, Sumatra, China, Japan.

AMPHORA EXIGUA Greg. Plate 2, fig. 11.

Length, 0.0204 mm; breadth, 0.0025; striæ, 15 to 17 in 0.01 mm. Geographic distribution: Scotland, Arctic America, Adriatic Sea, Sandwich Islands, Tahiti, West Indies.

AMPHORA TERRORIS Ehrenb.

Length, 0.034 mm; breadth, 0.0042; striæ, 12 in 0.01 mm. Geographic distribution: Arctic America, Kara, North, and Mediterranean Seas, Gulf of Mexico.

AMPHORA ANGUSTA (Greg.) Cleve var. TYPICA Cleve.

Length, 0.0544 mm; breadth. 0.0085; striæ, 14 in 0.01 mm.

AMPHORA COSTATA W. Sm. Plate 2, fig. 15.

Length, 0.0357 to 0.0765 mm; breadth, 0.0085; striæ, 7.5 in 0.01 mm; puncta, 8 to 9 in 0.01 mm. Geographic distribution: North, Mediterranean, and Adriatic Seas, Sumatra, Campeachy Bay.

AMPHORA MARINA (W. Sm.) V. Heurck.

Length, 0.0323 mm; breadth, 0.0153; striæ, 18 in 0.01 mm. Geographic distribution: North Sea, China.

NITZSCHIA APICULATA Greg. var. LIAOTUNGIENSIS var. nov. Plate 2, fig. 16.

Valve round panduriform with acuminate ends. Length, 0.1115 mm; breadth, 0.0221; coarse striæ, 5.5 in 0.01 mm; fine striæ, 12 in 0.01 mm.

NITZSCHIA PUNCTATA Sm. var. COARELATA Grun. Plate 1, fig. 29.

Length, 0.0561 mm; breadth, 0.0119; striæ, 10 to 11 in 0.01 mm. North Sea.

NITZSCHIA PANDURIFORMIS Greg.

Length, 0.0374 mm; breadth, 0.0153; coarse striæ, 7 to 8; fine striæ, 15 in 0.01 mm.

NITZSCHIA PANDURIFORMIS Greg. var. MINOR Grun. Plate 1, fig. 28.

Length, 0.034 mm; breadth, 0.0136; striæ, 18 to 20 in 0.01 mm. North Sea.

NITZSCHIA INTERCEDENS Grun. Plate 2, fig. 18.

Length, 0.26 mm; breadth, 0.0136; coarse striæ, 6.5 in 0.01 mm. Mediterranean Sea.

NITZSCHIA SIGMA Kütz. var. HABIRSHAWII Febiger.

Peragallo, Diat. de France. pl. 74, fig. 5.

Length, 0.2732 mm; breadth, 0.009; coarse striæ, 5 to 6 in 0.01 mm; fine striæ, 24 in 0.01 mm.

NITZSCHIA SOCIALIS Greg.

Length, 0.0731 mm; breadth, 0.006; coarse lines, 7 in 0.01 mm; fine lines, 17 to 18 in 0.01 mm.

NITZSCHIA SPATHULATA Bréb. Plate 2, fig. 17.

Length, 0.102 mm; breadth, 0.0119; striæ, 4 in 0.01 mm.

NITZSCHIELLA LONGISSIMA Kütz. forma TYPICA V. Heurck. Plate 2, fig. 20.

Length, 0.306 mm; breadth, 0.0068; coarse striæ, 5 in 0.01 mm.

NITZSCHIELLA INCURVA Grun. Plate 2, fig. 19.

Length, 0.0782 mm; breadth, 0.0042; striæ, 14 to 15 in 0.01 mm. Black Sea.

ILLUSTRATIONS

Plate 1

Fig. 1. *Licmophora gracilis* Ehrenb.
2. *Campylodiscus intermedius* Grun.
3. *Surirella fluminensis* Grun.
Figs. 4 and 5. *Surirella fastuosa* Ehrenb. var. *cuneata* A. Sm.
Fig. 6. *Campylodiscus samoensis* Grun.
7. *Surirella fastuosa* Ehrenb.
8. *Cocconeis scutellum* Ehrenb. var. *japonica* var. nov.
9. *Cocconeis scutellum* Ehrenb. var. *ornata* grun.
10. *Diploneis aestiva* Donk. forma β.
11. *Surirella liaotungiensis* sp. nov.
12. *Surirella liaotungiensis* sp. nov. var. *minuta* var. nov.
13. *Surirella gemma* Ehrenb.
Figs. 14 and 15. *Cocconeis pseudomarginata* Greg. var. *Formosa* var. nov.
Fig. 16. *Navicula crucicula* W. Sm. var. orientalis var. nov.
17. *Diploneis lineata* Donk.
18. *Diploneis chersonensis* Grun.
19. *Navicula liber* W. Sm. var. *genuina* Cleve.
20. *Amphora bigibba* Grun.
21. *Navicula liber* W. Sm. var. *linearis* Grun. f. *orientalis* f. nov.
22. *Navicula liber* W. Sm. var. *elongata* Grun.
23. *Navicula liber* W. Sm. var. *genuina* Cleve f. *sinica* f. nov.
24. *Navicula halophila* Grun. var. *brevis* var. nov.
25. *Navicula* (*Schizonema*) *ramosissima* Ag.
26. *Navicula liaotungiensis* sp. nov.
27. *Navicula granulata* Bail.
28. *Nitzschia panduriformis* Greg. var. *minor* Grun.
29. *Nitzschia punctata* Sm. var. *coarctata* Grun.
30. *Stauroneis pellucida* Cleve var. *orientalis* var. nov.

Plate 2

Fig. 1. *Trachyneis aspera* Ehrenb. var. *orientalis* var. nov.
2. *Pleurosygma normanii* Ralfs.
3. *Pleurosygma formosum* W. Sm.
4. *Pleurosygma elongatum* W. Sm.
5. *Pleurosygma balticum* Ehrenb.
6. *Pleurosygma diminutum* Grun.
7. *Pleurosygma speciosum* Sm.
8. *Amphora decussata* Grun.
9. *Amphora rhombica* Kitton var. *sinica* var. nov.
10. *Amphora ohgii* sp. nov.

FIG. 11. *Amphora exigua* Greg.
12. *Amphora proteus* Greg.
13. *Amphora ostrearia* Bréb. var. *typica* Cleve.
14. *Triceratium favus* Ehrenb.
15. *Amphora costata* W. Sm.
16. *Nitzschia apiculata* Greg. var. *liaotungiensis* var. nov.
17. *Nitzschia spathulata* Bréb.
18. *Nitzschia intercedens* Grun.
19. *Nitzschiella incurra* Grun.
20. *Nitzschiella longissima* Kütz. f. *typica* V. Heurck.

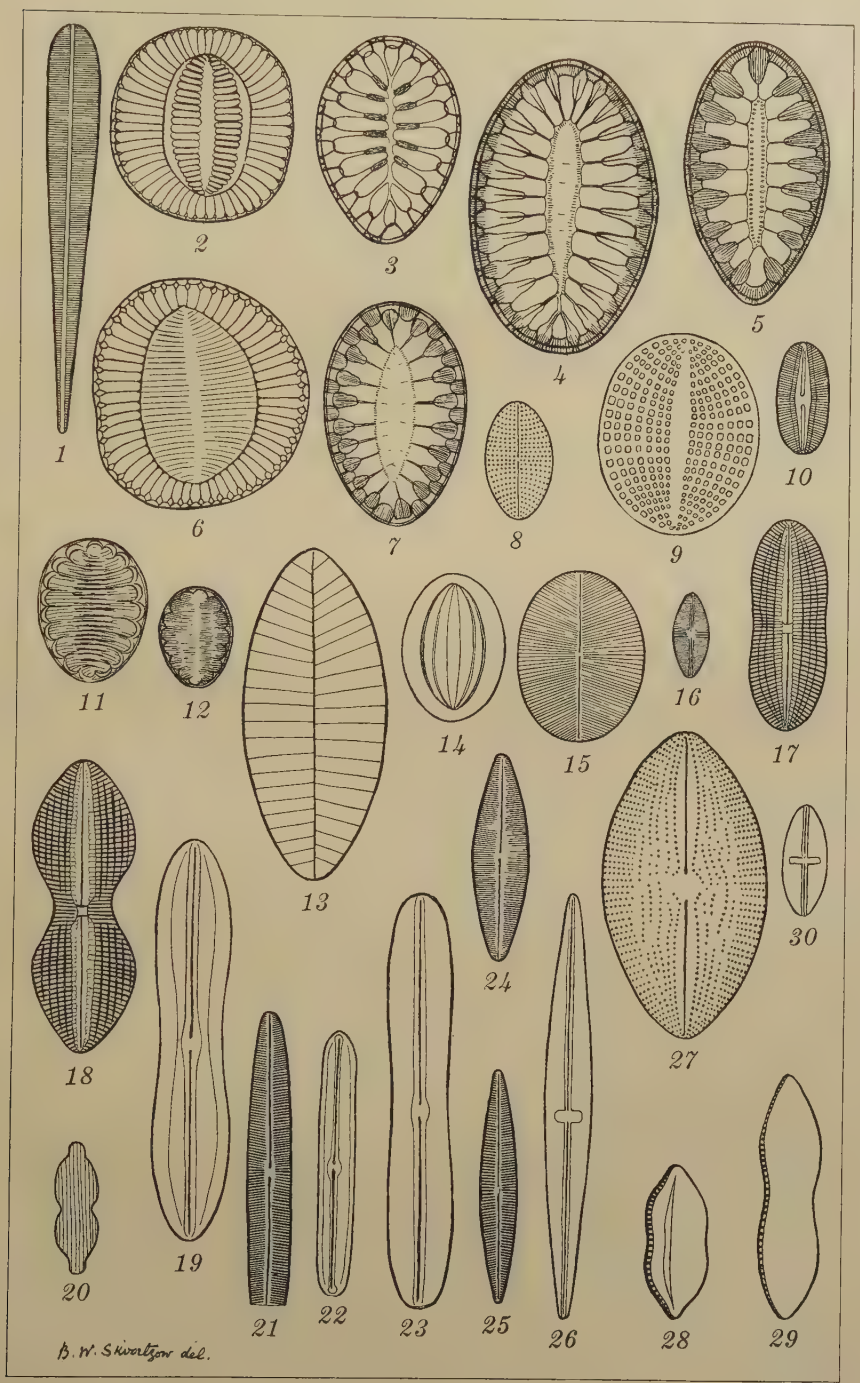
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PLATE 1.

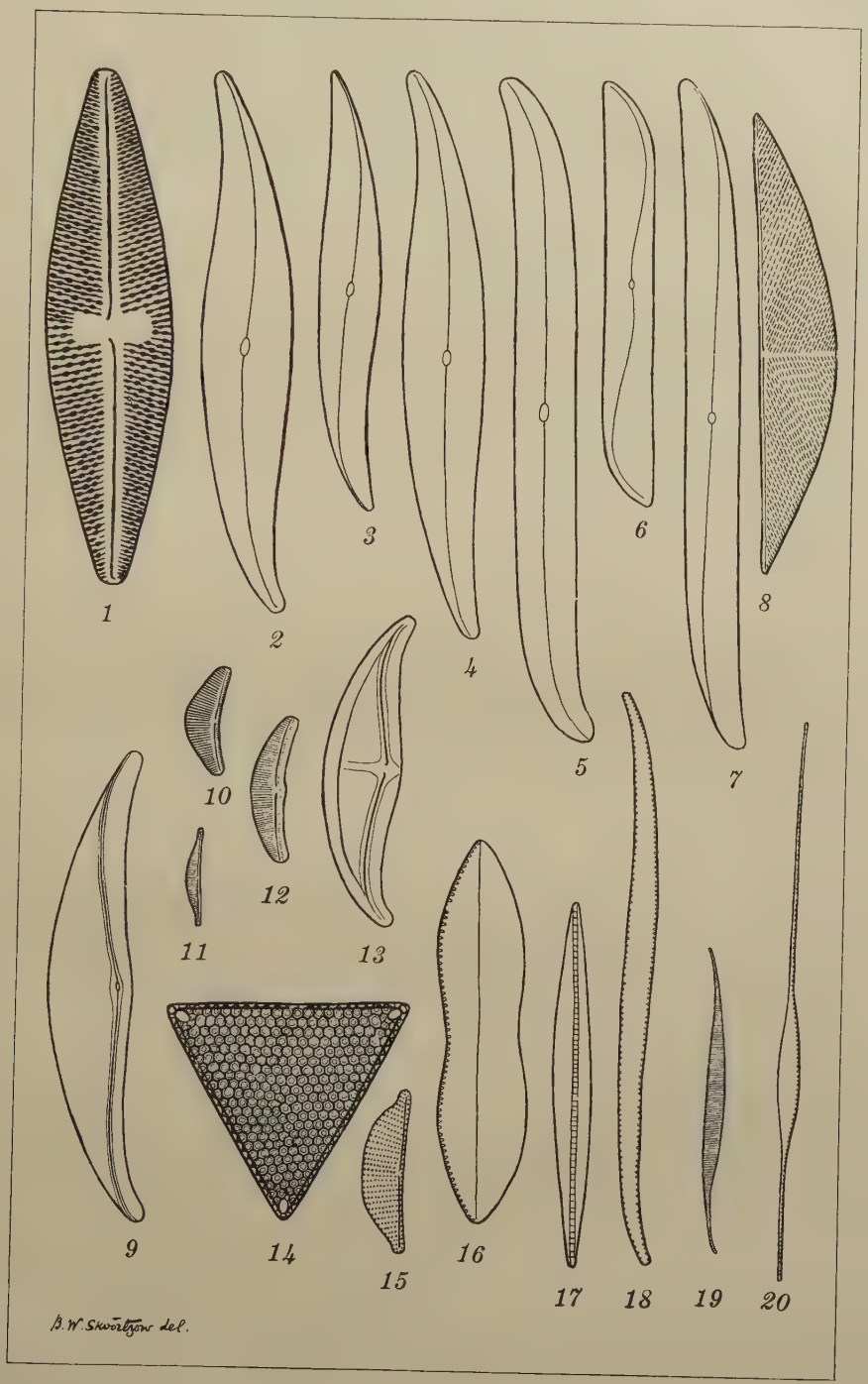

PLATE 2.

THE BUCCOPHARYNGEAL ARMATURE OF PHILIPPINE ANOPHELINES

By C. MANALANG

Of the Philippine Health Service, Manila

FOUR PLATES

Sinton and Covell [1] and later Barraud and Covell [2] dissected the buccopharyngeal armature of the females of eighty-six species of anophelines. The latter workers arranged the members of the genus *Anopheles* into five classes according to the character of the buccopharyngeal armature as follows: Class A, armature absent; Class B, armature consists of a single row of large separate pectenate teeth, 8 to 10 in number with two exceptions, *A. aureosquaminger* and *A. watsoni,* which have 12 to 14; Class C, armature of two rows of teeth very markedly curved so that their ends are directed forwards. Posterior hard palate cobble-stoned; Class D, armature of a double row of teeth without deep-set roots with 12 to 14 teeth in each row except in *A. ramsayi* which has 8; Class E, armature of a double row of teeth there being 18 to 26 in each row except *A. ludlowii* and *A. parangensis* which have 14 to 16. The teeth have long, deep-set, narrow bases, and their line of origin forms a strongly pronounced curve.

The present paper is a study of the buccopharyngeal armature of the commonest species of Philippine anophelines; namely, *Anopheles minimus* Theobald, *A. ludlowii* Theobald, *A. subpictus* Grassi, *A. vagus* Donitz, *A. kochi* Donitz, *A. tesselatus* Theobald, *A. philippinensis* Ludlow, *A. fuliginosus* Giles, *A. hyrcanus* Wiedemann, *A. barbirostris* Van der Wulp, *A. maculatus* Theobald, *A. karwari* James, and an unnamed one probably a new species.

TECHNIC

The head is macerrated in 10 to 15 per cent caustic potash aided by a few minutes boiling. As soon as the eyes are trans-

[1] Indian Journ. Med. Research 15 No. 2 (1927).
[2] Indian Journ. Med. Research 15 No. 3 (1928).

parent (Plate 1, fig. 1) the specimen is washed in water and dissected in a drop of water on a slide under a dissecting microscope. The entire buccopharyngeal skeleton with the clypeus and both epipharynx and hypopharynx can be isolated with very little difficulty, by placing a needle at the occiput and pulling the skeleton by forward traction with another needle on the clypeus. The excess of water is drained off with filter paper. For observation place the specimen, by the use of needles, in a dorsoventral position under the dissecting microscope; and allow it to dry slowly over a small alcohol flame. The angle at the buccopharyngeal junction and the prominence and weight of the clypeus (Plate 1, fig. 2) often cause the specimen to fall on the side when applying the cover glass. This may be avoided by carefully breaking off the clypeus and slightly crushing the pharyngeal bulb dorsoventrally. A small amount of albumen fixative added to the drop of water while dissecting helps in keeping the specimen in position while it is drying. The specimen when thoroughly dry is mounted in Canada balsam. Air bubbles are frequently captured in the buccopharyngeal cavity and obliterate the armature. These are removed by heating the slide over the flame.

FINDINGS

The results of the present work on twelve of the commoner anopheline species in the Philippines show them to belong in either of the four classes A, B, D, and E but none in Class C. The unnamed species belongs to class B. It has a single row of eight large separate pectenate teeth (Plate 4, fig. 16). We have been unable to identify the name of this mosquito among those described in the Orient in the limited literature available. For this reason a brief description of the larva and adult female is here given.

LARVA

Habitat.—Eddies on sides of streams in Kolambugan, Lanao, Mindanao; associated with *A. minimus* and of the same size. Recognized by white bands on the anterior half of the thorax, and on second, fifth, and last two abdominal segments.

Head.—Inner anterior clypeal hair stout and minutely frayed; outer anterior clypeal hair about one-fifth as long as the inner; closely approximated to it, with three stout branches. Preantennal hair with four to five branches and about as widely approximated as the inner anterior clypeal hairs. Vertical hairs basally biped; and transutural hair with three branches.

Thorax.—Anterior half conspicuously light in color, and dark posteriorly. Inner anterior submedian thoracic hair heavily branched as in *Anopheles minimus* Theobald, about one-half as long as the central and lateral submedian thoracic hairs; palmate hair very rudimentary.

Abdomen.—Second, fifth, and the last two abdominal segments conspicuously light in color which does not disappear in 10 per cent formalin as preservative. Palmate hair of first and second abdominal segments poorly developed. Palmate hairs 18 to 22 leaflets; lanceolate in shape and not filamentous distally. Antepalmate hair simple.

ADULT FEMALE, HEAD; ANTENNÆ MISSING

Probocis.—Labella brown followed by a narrow black band. Then a white band of the same width and black shaft.

Palpi.—With five white bands, the apical yellowish, the second white band from the apical very broad and separated from it by a narrow black band. Two narrow black bands separated by a narrow white follow the second white band. The fourth and fifth white bands are separated by a broad black band.

Thorax.—Dorsum silvery white with three faint narrow brown lines running anteroposteriorly and two black eye spots just anterior to the middle prominence. Halteres covered with white scales.

Wings.—The costa with eight black spots, four of which involve the first vein. Three spots are large, one near the apex, one at the middle being the largest and one one-third the distance from the base.

Abdomen.—Segments with lateral tufts of hair and scales except the first and second segments.

Legs.—Femora, tibia, and first tarsal markedly spotted with narrow white bands at the tarsal articulations.

COMMENTS

Barraud and Covell's lists of species under each class of buccopharyngeal armature contain all the Philippine species studied except the list under Class C and the results of the present study confirm their observations except in the case of *A. ludlowii.* They include this species in Class E, but specify that it has only 14 to 16 teeth to each row instead of 18 to 26. The Philippine *A. ludlowii,* however, seems to be different. We recognize *A. ludlowii* by the palpal distal black band being equal in width to or one-half or more of the apical white band, by the *A. rossii*

type of wing markings; and with spotted femora and tibia. We seem to have two varieties of *A. ludlowii;* one variety, a small one with spotted legs the distal black palpal band equal to the apical white, and with 16 teeth; and a larger variety also with spotted legs but the distal black palpal band narrower than the apical white with 24 to 26 teeth like those found in *A. subpictus* and *A. vagus.* The spotting of the legs is our main criterion in differentiating *A. ludlowii* from what we call *A. subpictus.* If this is adhered to, then we have two varieties of *A. ludlowii.* If the number of teeth in the buccopharyngeal armature is to be followed, however, then we have two varieties of *A. subpictus,* one with spotted legs and another without.

Further study in this respect is called for, because we have no direct evidence against *A. ludlowii* as a malaria transmitter in the Philippines, although it is a confirmed vector in other countries. A study of the armature of the *A. ludlowii-vagus* group in other countries is also indicated with a view of standardizing their nomenclature because there seems to be a confusion of names in this group.

ILLUSTRATIONS

[Photomicrographs by C. M. Urbino, Malaria Control Section, Philippine Health Service.]

Plate 1

Fig. 1. Cleared head of *A. minimus*, dorsoventral view; × 100.
2. Buccopharyngeal skeleton of *A. subpictus*, lateral view; about × 100.
3. Buccopharyngeal junction of *A. hyrcanus*, dorsoventral view; about × 330. Class A (no teeth).
4. Buccopharyngeal junction of *A. barbirostris*, dorsoventral view; × 330. Class A (no teeth).

Plate 2

Fig. 5. Buccopharyngeal junction of *A. kochi* with armature of large separate pectenate teeth, dorsoventral; × 330. Class B.
6. Buccopharyngeal armature of *A. tesselatus*, dorsoventral; × 330. Class B.
7. Buccopharyngeal armature of *A. maculatus*, dorsoventral; × 330. Class D.
8. Buccopharyngeal armature of *A. fuliginosus*, dorsoventral; × 330. Class D.

Plate 3

Fig. 9. Buccopharyngeal armature of *A. philippinensis*, dorsoventral; × 330. Class D.
10. Buccopharyngeal armature of *A. minimus*, dorsoventral; × 330. Class D.
11. Buccopharyngeal armature of *A. karwari*, dorsoventral; × 330. Class D.
12. Buccopharyngeal armature of *A. ludlowii*, palpal apical black band narrower than the apical white band; 22 teeth visible; dorsoventral; × 330. Class E.

Plate 4

Fig. 13. Buccopharyngeal armature of *A. ludlowii;* palpal apical black band equal in width to the apical white band; 14 teeth visible; dorsoventral; × 330. Class E.
14. Buccopharyngeal armature of *A. subpictus*, dorsoventral; × 330. Class E.
15. Buccopharyngeal armature of *A. vagus*, dorsoventral; × 330. Class E.
16. Buccopharyngeal armature of the Kolambugan species (undetermined) with large separate pectenate teeth, dorsoventral; × 330. Class B.

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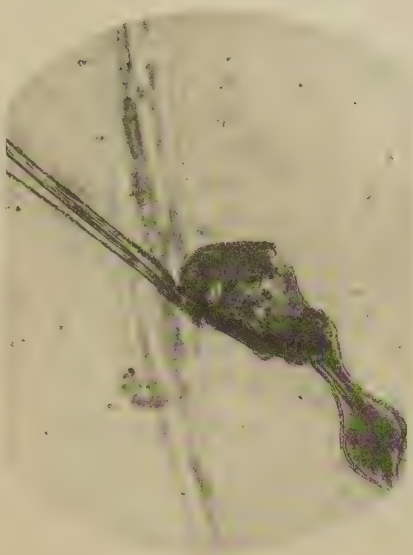

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PLATE 1.

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PLATE 2.

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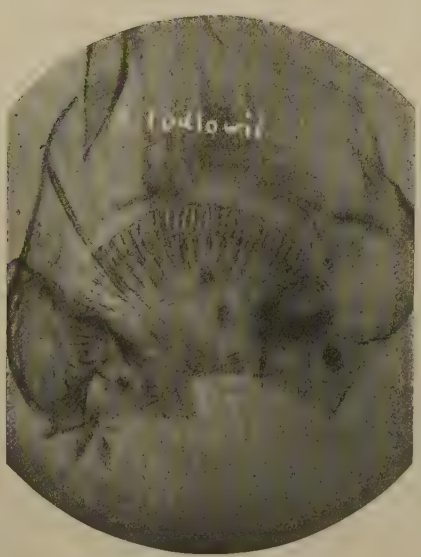

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PLATE 3.

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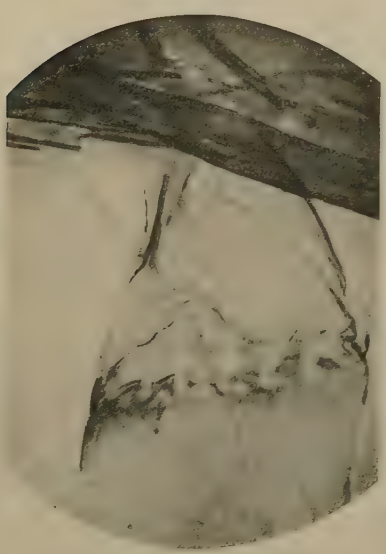

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PLATE 4.

REPORT OF A CASE OF RHINOSPORIDIOSIS

By C. MANALANG

Of the Philippine Health Service, Manila

THREE PLATES

Castellani and Chalmers [1] define rhinosporidiosis as a "chronic infection caused by *Rhinosporidium seeberi* Wernicke, 1900, and characterized by the production of polypi on the mucous membrane and papillomata on cutaneous surfaces."

According to these authors the disease was first recognized by Malbran in 1892 in South America, and by Seeber in 1896 in Buenos Aires. Wernicke named the parasite *Coccidium seeberi* in 1900. Kenealy in 1894 found a pedunculated, raspberry-like body on the nasal septum of an Indian in Calcutta and reported it in 1903 as having peculiar bodies embedded in the tissues. Minchin and Fantham called these bodies *Rhinosporidium kinealyi.* Other reports were those of Nair on the west coast of India in 1905, Beattie in 1906 in Cochin, Castellani and Chalmers in 1910, and Cheliah in 1918—the last two from Ceylon. According to Beattie [2] the disease is very frequent among the natives of the state of Cochin. Blanchard studied a case from Argentine. Manson-Bahr [3] mentions that the parasite has also been recorded in the United States.

As described by Castellani and Chalmers the parasite in sections consists of cysts which may be oval, round, tubular, branched or irregular bodies lying mostly below the epithelium. The cyst wall is thin and has either an opening or a conical elevation at one point. The smaller cysts contain undifferentiated protoplasm with a nucleus, the larger ones with one or more definite chromatic masses while the well-developed cysts are filled with matured pansporoblasts located in the center with young ones in the periphery. The matured pansporoblast contains sixteen spores and is liberated by rupture of the cyst wall. The cysts vary in diameter from 10 to 30 microns when young and from 200 to 300 microns when mature.

[1] Manual of Tropical Medicine 3d ed.

[2] Brumpt, Nociones de Parasitologica 96.

[3] Manson's Tropical Diseases 8th ed. (1925) 625.

The parasite was originally considered a protozoan allied to *Coccidium*, but Manson-Bahr cites Asworth (1923) as having shown the organism as probably a yeast or phycomycete. This view is also held by Chandler.[4] Ashworth had only partial success in cultivating the parasite, and the spores multiplied slowly on Saboraud's medium.

According to Rivas [5] the life history of this parasite is apparently very simple, and he describes the asexual reproduction as follows:

> On entering the host the young trophozoite becomes encysted, multiplies and gives rise to a multinucleated mass of protoplasm that divides forming several sporoblasts (pansporoblasts) containing the merozoites or spores. When the cyst ruptures, these spores are set free, invade the surrounding tissues, grow into trophozoites, and the cycle is repeated. Sexual reproduction is not known.

The infection is probably acquired directly or indirectly through abrasions in the mucosa.

Lesions.—The parasite is supposed to produce polyps in the nose or ears which often recur after removal. Castellani and Chalmers mention the production of papillomata on cutaneous surfaces, for example the penis, while Byam and Archibald [6] state that the parasite, though rarely, also attacks the conjunctiva and skin of the eyelids, where it also forms polypoid growths. The appearance of the growth is said to be distinctive in that the edges are semitransparent with a band of fibrous tissue running through the middle. According to Chandlers it has been suggested that polypi in the nose due to this parasite may have the same influence on the intellect as the nonparasitic ones. According to Rivas, "the main lesion consists of proliferation of the nasal mucosa and submucosa caused by the irritation set up by the parasite." Castellani and Chalmers suspect that the infections may be give rise to a septicæmic or generalized infection in which case the prognosis would be bad.

Treatment.—According to Manson-Bahr, the treatment "consists in removing the polypi from the nares by means of a wire snare. Medical treatment would not appear to be indicated, although Wright has reported that the tumors disappear after

[4] Animal Parasities and Human Disease 3d ed. John Wiley & Sons (1926) 173.

[5] Human Parasitology. W. B. Saunders (1920) 150.

[6] Practice of Medicine in the Tropics. Oxford Medical Publication 3 (1923) 2293.

intravenous injections of tartar emetic." Castellani and Chalmers recommend cauterization of the base after removal of the growth.

CASE REPORT

The material for this report consists of fragments of white, friable, papillomatous tissue preserved in 10 per cent formalin and labelled "nasal polyps." The polyps were sent by Dr. S. Y. Orosa, of the Philippine Health Service Provincial Hospital, Occidental Negros, with a note that they were removed from a Filipino boy of 7 years, residing in the Municipality of Talisay. No other data were furnished.

Pieces of tissues were embedded in parrafin, sectioned, and stained with hæmatoxylin-eosin. Histologic examination (Plate 1, fig. 1) showed numerous various-sized spherical cysts with distinct wall, widely distributed throughout the tissue including a few in the mucous lining (Plate 1, fig. 2). The cysts varied from 10 to 200 microns in diameter. Some of the cysts were oval, while few were tubular, crescent-shaped, or irregular (Plate 1, fig. 1). These different shapes were probably mechanical, for the cysts all appeared spherical in potash preparation (Plate 2, fig. 3). Most of the cysts contained granular or hyalinelike material, often vacuolated, and with occasional nuclear bodies. Few of the smaller cysts contain a dark-staining substance, as if indicating a tendency to calcification (Plate 2, fig. 4). Few eosinophiles were seen in some areas of the myxomatous tissue surrounding these cysts. Occasional groups of round cells with polynuclears were seen, as if tending to miliary-abscess formation (Plate 3, fig. 5). No necrotic nor fibrosed areas were observed except the centrally located fibrous core of the growth. The bulk of the growth is myxomatous tissue with some thickening of the mucous covering. The tissue was not particularly vascular. Teased portions of the bits of tissue in formalin examined under a cover slip or, better still, bits of tissues when boiled for a few minutes in 10 to 15 per cent potassium hydrate solution showed the nature of these cysts better than sections (Plate 2, fig. 3). With this preparation many, small, scattered, refractile bodies (pansporoblasts) of about 8 microns in diameter, containing half a dozen or more refractile spores, were seen. Large matured cysts were filled with pansporoblasts, which poured out in large numbers when the cyst wall was broken by pressure on the cover slip (Plate 3, fig. 6).

The literature consulted seems to be unanimous that the parasite produces polyps and papillomata rather than an accidental infection of an already existing growth, although it would appear that there should be more tissue reaction unless the tumor formation is the reaction itself. The extensive distribution of the cysts below the mucosa and the presence of only a few cysts in the mucosa certainly favor the etiologic relationship of the parasite with the disease. It cannot be determined if the parasite in the present case is identical with *Rhinosporidium seeberi* Wernicke or with *Rhinosporidium kinealyi* Minchin and Fantham, but the material as described and illustrated leaves very little doubt as to its nature.

Whether or not the infection is common in the Philippines, can be shown only by a systematic examination of tissues removed from children in various parts of the Islands. As far as I can find, this is the first reported case of rhinosporidiosis in the Philippines.

ILLUSTRATIONS

[Photomicrographs by E. Cortes, Bureau of Science.]

Sections of a polyp from a case of rhinosporidiosis in the Philippine Islands

PLATE 1

FIG. 1. Section of the polyp showing thickened mucosa at *a*, with a few round cells at *b*; *c* and *d* indicate crescent and irregularly shaped cysts, respectively. × 100.

2. A portion of the polyp showing two cysts, *a* and *b*, in the mucosa. The other cysts are in the submucosa. × 400.

PLATE 2

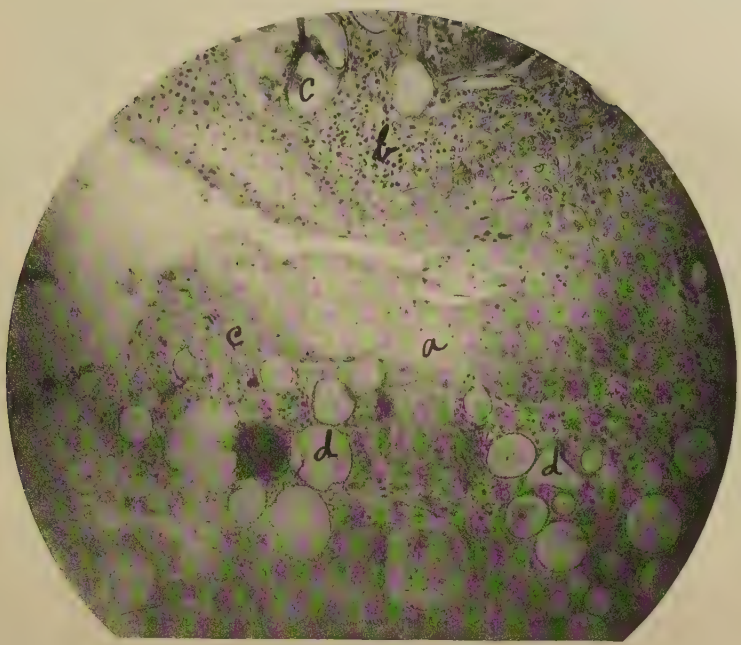
FIG. 3. Potassium hydrate preparation showing all stages of the cysts. The cysts are spherical in shape.

4. A portion of the polyp showing about a dozen small cysts, *x*, which stained dark as if calcified. × 100.

PLATE 3

FIG. 5. A portion of the polyp with apparently beginning milliary abscess. × 100.

6. Teased preparation showing a matured cyst ruptured by pressure on the cover glass. The cyst is filled and surrounded by a large number of young and full-grown pansporoblasts, the former occupying the upper half of the cyst. × 140.



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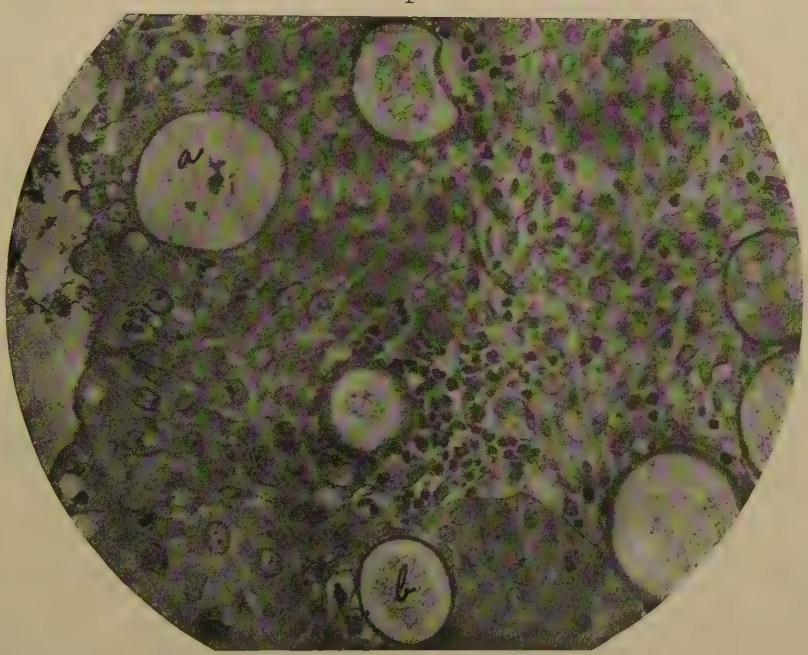

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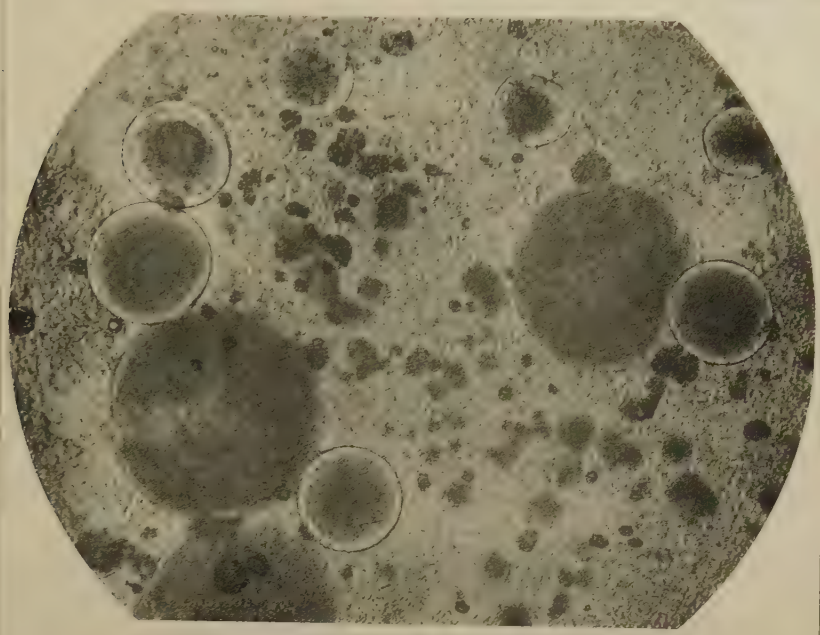

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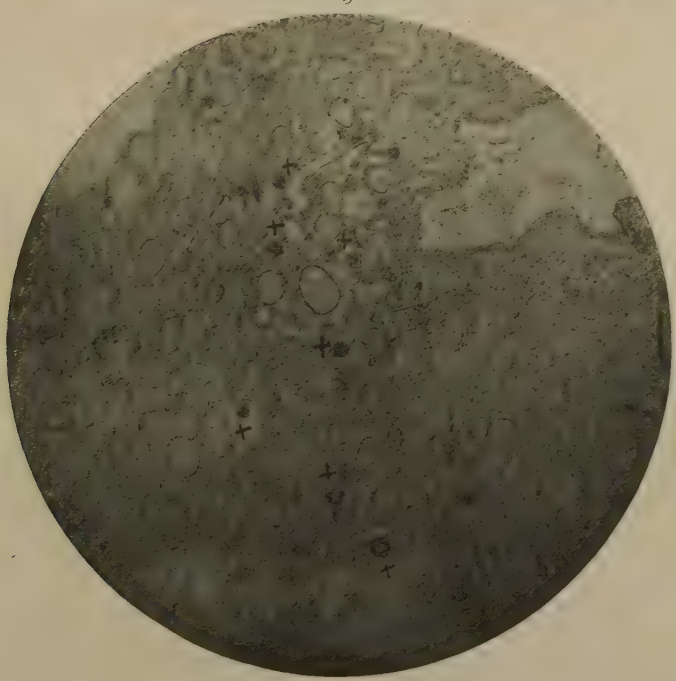

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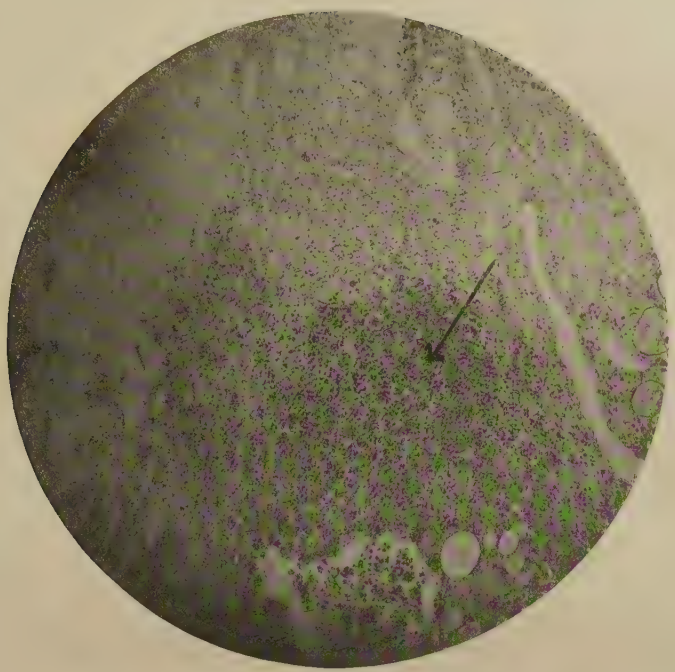

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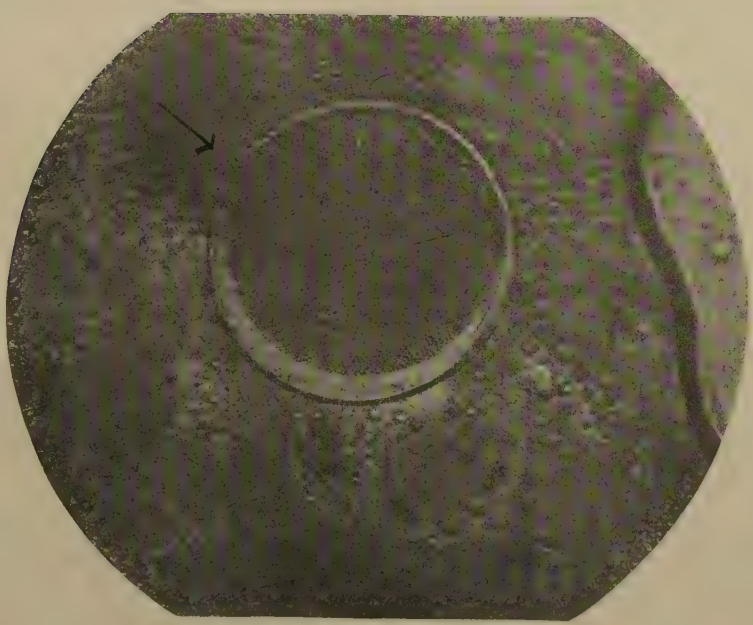

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PLATE 3.

PARADISTOMUM GREGARINUM, A NEW NAME FOR THE TREMATODE PARADISTOMUM MAGNUM

By MARCOS A. TUBANGUI

Of the University of the Philippines, Los Baños

In a paper on the trematode parasites of Philippine vertebrates [1] I described a trematode from the gall bladder of a lizard under the name *Paradistomum magnum.* Dr. Albert Hassall, of the United States Bureau of Animal Industry, has kindly called my attention to the fact that this name is preoccupied by *Paradistomum magnum* Travassos, 1920, for which reason I propose the new name *Paradistomum gregarinum* to replace *Paradistomum magnum* Tubangui, 1928.

I wish also to call attention to the following errata to the same paper:

Page 353, lines 6 and 13 from the top, for *Stepoda* read *Stegopa.*

Page 363, line 9 from the top, *for* Plate 5, *read* Plate 4; line 14 from the bottom, *for* fig. 3, *read* fig. 4.

Page 364, line 21 from the bottom, *for* fig. 4, *read* fig. 3.

Page 367, line 11 from the top *for* Plate 7, fig. 2, *read* Plate 5, fig. 3.

Page 371, under Plate 4, Fig. 3 *should be* Fig. 4 *and* Fig. 4 *should be* Fig. 3.

[1] Philip. Journ. Sci. 36 (1928) 351–371.

CHAULMOOGRYL AMINO PHENOLS AND CHAULMOOGRYL BENZYLAMINE

By Irene de Santos and Augustus P. West

Of the Bureau of Science, Manila

Various derivatives of chaulmoogric acid, such as esters, have been made from chaulmoogra oil.[1] In the present investigation, a few chaulmoogryl amino phenols and chaulmoogryl benzylamine were prepared. The method of preparation consisted in treating the acid amide of chaulmoogric acid with the chlor phenols or benzyl chloride in the presence of metallic copper (Goldberg's reaction).[2] The results seem to indicate that these compounds may be prepared rather easily though these reactions take place somewhat slowly. The new compounds prepared in this research will be tested for their therapeutic value. In order to check the formulas of these compounds, the nitrogen content was determined. A modification of Meulen's catalytic method [3] was employed for making the nitrogen analyses.

EXPERIMENTAL PROCEDURE

The chaulmoogra oil used in this investigation was kindly presented to us by Dr. H. I. Cole, of the Philippine Bureau of Health, and was shipped directly to us from the Culion Leper

[1] Power, F. B., and F. H. Gornall, Journ. Chem. Soc. Trans. 85 (1904) 838 and 851.—Power, F. B., and M. Barrowcliff, Journ. Chem. Soc. Trans. 91, 1, (1907) 557.—Shriner, R. L., and Roger Adams, Journ. Am. Chem. Soc. 47 (1925) 2727.—Perkins, G. A., Philip. Journ. Sci. 24 (1924) 621.—Perkins, G. A. and A. O. Cruz, Journ. Am. Chem. Soc. 49 (1927) 1070.—Perkins, G. A., Journ. Am. Chem. Soc. 48 (1926) 1714.—Van Dyke, R. H., and Roger Adams, Journ. Am. Chem. Soc. 48 (1926) 2393.—Sacks. J., and Roger Adams, Journ. Am. Chem. Soc. 48 (1926) 2395.—Dean, A. L., R. Wrenshall, and G. Fujimoto, Journ. Am. Chem. Soc. 47 (1925) 403.—Noller, C. R., and Roger Adams, Journ. Am. Chem. Soc. 48 (1926) 1080.—Herrera-Batteke. P. P., and A. P. West, Philip. Journ. Sci. 31 (1926) 161.—Santiago, S., and A. P. West, Philip. Journ. Sci. 33 (1927) 265.—Santiago, S., and A. P. West, Philip. Journ. Sci. 35 (1928) 405.— de Santos, I., and A. P. West, Philip. Journ. Sci. (in press).

[2] Goldberg, I., Ber. Deut. Chem. Gesell. 39 (1906) 1691.

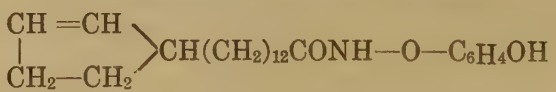
[3] Smith, F. L., and A. P. West, Philip. Journ. Sci. 31 (1926) 265.

Colony. The oil was prepared from the seeds of *Hydnocarpus alcalæ* C. de Candolle.

The chaulmoogric acid and the acid amide of chaulmoogric acid were prepared according to the procedure used by Santiago and West.[4] Chaulmoogra oil (600 grams) was saponified with alcoholic potassium hydroxide (200 grams dissolved in 80 cubic centimeters of water and 800 cubic centimeters of aldehyde-free alcohol). The mixture was heated (reflux) on a water bath for about four hours, after which the excess alcohol was removed by distillation. The residual soaps were decomposed with dilute sulphuric acid (1:3) and the free acids extracted with ether. The ether extract was dehydrated with anhydrous sodium sulphate, after which the solution was distilled to eliminate the ether. The residue was treated with gasoline, and the precipitated resins were separated from the acid by filtering. The gasoline was then removed by distillation and the residue crystallized several times from alcohol (95 per cent). The melting point of the chaulmoogric acid was 68° C.

The acid chloride of chaulmoogric acid was prepared by treating melted chaulmoogric acid with phosporus trichloride. The reaction was finished in about fifteen minutes. The reaction product was filtered through glass wool to remove the viscous phosphorous acid, and the clear filtrate consisting of the acid chloride of chaulmoogric acid was allowed to drop slowly into cold concentrated ammonia. The precipitated amide was washed with water and dried. The amide was then dissolved in methyl alcohol, the solution decolorized with bone black, and allowed to crystallize. The amide was then recrystallized from xylene and finally from absolute alcohol. The melting point was 104 to 105° C.

CHAULMOOGRYL O-AMINO PHENOL



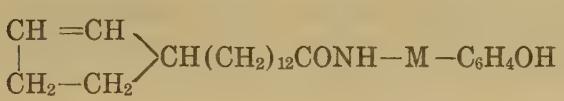
This compound was prepared by treating the acid amide of chaulmoogric acid with *o*-chlor phenol in the presence of powdered metallic copper which was prepared by reducing powdered black copper oxide in a current of hydrogen. Ten grams of

[4] Philip. Journ. Sci. 33 (1927) 265.

chaulmoogramide were placed in a round flask, and 0.2 gram of powdered copper was added to the amide. Ortho chlor phenol (6.3 cubic centimeters) and 5 grams of powdered fused sodium acetate were added to the mixture. The use of the sodium acetate was to neutralize the hydrochloric acid evolved during the reaction. The flask was then connected to a reflux condenser and heated in a Crisco oil bath to a temperature of about 125° C. until no more acid vapors were evolved, which required about three days. The black solid reaction product was dissolved in methyl alcohol and filtered to eliminate the copper catalyst. The solution was decolorized with animal charcoal and allowed to crystallize. The product was then crystalized three more times from methyl alcohol. White crystals melting at 104.9 to 105.9° C. were obtained. The chaulmoogryl *o*-amino phenol was found to be soluble in the common organic solvents. The yield was about 15 per cent.

Analysis:	Nitrogen. Per cent.
Calculated for $C_{24}H_{37}O_2N$	3.77
Found	3.94

CHAULMOOGRYL M-AMINO PHENOL

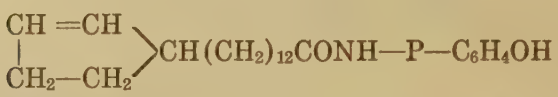


This compound was prepared by treating the acid amide of chaulmoogric acid with *m*-chlor phenol in the presence of copper. Chaulmoogramide (15 grams) was placed in a round flask and to this were added 9.4 cubic centimeters of *m*-chlor phenol, 7.5 grams of anhydrous sodium acetate, 0.2 gram of powdered copper, and 120 cubic centimeters of nitrobenzene. The mixture was heated (reflux) over a wire gauze until no more acid vapors were evolved. The reaction product, which was a black mass, was dissolved in ethyl alcohol and filtered to remove the copper catalyst. The alcoholic solution was then distilled in a current of alcohol vapor in order to remove most of the nitrobenzene. The alcoholic solution of the reaction product was diluted somewhat with alcohol, decolorized with animal charcoal, and allowed to crystallize. After recrystallizing in methyl alcohol, white crystals melting at 105.9 to 108° C. were obtained. The yield was about 5 per cent. The compound is soluble in the common

organic solvents, with the exception of petroleum ether in which it is only slightly soluble.

Analysis:	Nitrogen. Per cent.
Calculated for $C_{24}H_{37}O_2N$	3.77
Found	3.93

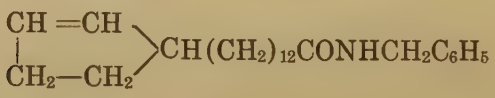
CHAULMOOGRYL P-AMINO PHENOL



The substance was made by the interaction of chaulmoogramide, *p*-chlor phenol, sodium acetate, and copper. Chaulmoogramide (10 grams) was placed in a round flask and treated with 7.82 grams of *p*-chlor phenol, 5 grams of anhydrous sodium acetate, and 0.2 gram of powdered copper. The mixture was heated (reflux) at a temperature of about 120° C. until no more acid vapors were evolved, which required about two days. The reaction product was dissolved in methyl alcohol and filtered to remove the catalyst. The solution was decolorized with animal charcoal and allowed to crystallize. After recrystallizing from methyl alcohol, white crystals melting at 97.8 to 101.9° C. were obtained. The yield was about 15 per cent. The compound is soluble in the common organic solvents but only slightly soluble in petroleum ether and carbon bisulphide.

Analysis:	Nitrogen. Per cent.
Calculated for $C_{24}H_{37}O_2N$	3.77
Found	4.08

CHAULMOOGRYL BENZYLAMINE



The chaulmoogryl benzylamine was obtained by heating a mixture consisting of 12 grams of chaulmoogramide, 8.38 cubic centimeters of benzyl chloride, 5 grams of anhydrous, fused sodium acetate, and 0.2 gram of powdered copper. The procedure was similar to that used in making the other chaulmoogryl derivatives. The crude reaction product was dissolved in methyl alcohol and filtered to remove the catalyst. The alcoholic solution was then decolorized with animal charcoal to which Kieselguhr was added in order to eliminate colloidal

substances. Crystals obtained from the alcoholic solution were recrystallized from methyl alcohol. The melting point was 92.7 to 95.8° C. The yield was about 22 per cent. The compound was soluble in most of the common organic solvents but only slightly soluble in carbon tetrachloride, xylene, and petroleum ether.

Analysis:	Nitrogen. Per cent.
Calculated for $C_{25}H_{39}ON$	3.79
Found	3.83

SUMMARY

Four new chaulmoogric compounds were prepared in this investigation. They are chaulmoogryl *o*-amino phenol, chaulmoogryl *m*-amino phenol, chaulmoogryl *p*-amino phenol, and chaulmoogryl benzylamine. These compounds are soluble in most of the common organic solvents.

BAÑGOS CULTURE IN THE PHILIPPINE ISLANDS

By ALBERT W. HERRE and JOSÉ MENDOZA

Of the Bureau of Science, Manila

SIXTEEN PLATES AND SIX TEXT FIGURES

INTRODUCTION

Of more than sixteen hundred kinds of fishes recorded from the Philippines, bañgos is the first in importance. It is by far the leading fish in Manila markets, and is the product of an industry in which over 45,000,000 pesos are invested around Manila Bay alone. Bañgos is the daily staple animal diet of tens of thousands of Manilans, and in the typhoon season is the only cheap fish available. Bañgos is shipped almost daily either by train or motor truck from Hagonoy, Bulacan, Navotas, and Malabon to various towns of Mountain, Pangasinan, Tarlac, Nueva Ecija, Bulacan, Pampanga, Laguna, Batangas, and Tayabas Provinces. In the interior towns of the above-named provinces bañgos in all forms finds a very good market and plays an important part in the diet of all classes.

Bañgos, like shad, is so excessively filled with minute bones that it is not eaten by people unaccustomed to it as long as the market is well supplied with fishes having fewer bones. The bañgos that is found in the markets ordinarily is just a few months old. The adult is seldom caught and is consequently rare; owing to its great size, fine bones are little evident and such a fish is exceedingly toothsome and commands a high price in all parts of the Islands.

In suitable natural localities, with fairly favorable marketing facilities the culture of bañgos is one of the most profitable industries in the Philippines. Throughout a large part of the Islands one monsoon may bring a glut of fish to the shores, with a corresponding scarcity during the opposite monsoon. In every such locality bañgos ponds are desirable and profitable, if the countryside is at all thickly settled, even though there is no large town close at hand.

During the rainy season there may be weeks in succession when no fish can be caught in the sea. At such times the bañgos grower reaps a harvest, if he has managed his fish properly; and he can usually obtain better prices than in Manila, because he has less competition.

Persons about to engage in bañgos culture are urged to spend sufficient time in the vicinity of Malabon to acquaint themselves with the most efficient methods of fishpond construction and of bañgos culture. Such things as the proper way of handling the flow of water, the care of the fry, and the growth of lablab and of lumut are better learned from example than from a book.

DESCRIPTION OF THE BAÑGOS

The bañgos, *Chanos chanos* (Forskål), is as beautiful as it is important commercially. It is a large, brilliant, shiny, silvery-white fish with a pale steel-bluish back. The compressed body, covered with small, smooth scales, has an almost regular spindle-shaped outline. There is a single fin at the back inserted just behind the highest point. The large tail is deeply forked. The head although small is in pleasing proportion. The mouth is terminal, oblique, and toothless. A thick gelatinous substance, very thick at the eye region, covers the snout up to the nape and the eye and its neighborhood.

FOOD OF THE BAÑGOS

The bañgos feeds upon diatoms and other plankton organisms, the leaves of submerged flowering plants, and algæ; it consumes large quantities of the filamentous green algæ. The fry feeds upon plankton and the surface scum on the muddy bottom of quiet shallow bays and tidal creeks. When food is plentiful the bañgos grows very rapidly.

DISTRIBUTION OF THE BAÑGOS

Although the bañgos was first described as coming from the Red Sea, it has a very wide distribution. It occurs throughout the Philippines, often entering the fresh-water rivers and lakes. It is found on all the coasts in the Indian Ocean as far south as Zanzibar, on the coasts of Asia and Formosa, and is seen occasionally along the coasts of southern Japan. In the Pacific, the bañgos may be found about Hawaii, Samoa, the East Indies, and the Society Islands and even as far south as

Australia and New Zealand. It is abundant in the Gulf of California and along the coast of Mexico.

In many parts of this immense range the bañgos is prized as food, in spite of the excessive number of fine bones. The flesh has a bland delicate flavor, and for this reason bañgos is sometimes called "milkfish." The bañgos is a fish of the open sea, and a swift and powerful swimmer. It rarely approaches land or enters shallow water except during March, April, and May. At that time some of them are caught in gill nets and fish corrals. The bañgos has such tremendous leaping power that it frequently escapes from nets and corrals. A bañgos two-thirds of a meter long can easily leap a distance of 10 or 12 meters, at the same time clearing obstructions 2 to 4 meters above the surface of the water. In a straight upward leap it can probably rise 5 or 6 meters from the water.

In the Philippines, as far as can be definitely ascertained, the bañgos spawns during April and May. It seems to spawn in quiet shallow sandy bays, where the fry are found along the shore in immense numbers.

EGGS OF THE BAÑGOS

The bañgos is among the most prolific of fishes. One of the ovaries of a ripe female taken in Subic Bay on April 10, 1927, measured 330 millimeters in length, 89 in extreme breadth (35 at the anterior, and 24 at the posterior, extremity), 40 in extreme thickness, and weighed 450 grams. The other ovary was equally large but had been damaged in removal. Bañgos eggs are very small. The ovaries of this specimen contained 3,415 eggs per gram. One ovary contained about 1,530,000 eggs; therefore, the fish had about 3,060,000 ripe eggs ready to spawn. This fish was about three-fourths of a meter in length. It is a safe assumption that fish half again as large would contain many more eggs.

In Batavia, Java, Dr. A. L. G. Seunier examined the roe of a fish 1,120 millimeters long, including the caudal fin (probably about 940 or 950 millimeters in real length). The roe weighed 1,304 grams, and one gram contained 4,370 eggs, making a total of about 5,700,000 eggs in the whole roe.

This shows that the number of eggs per gram varies considerably. Of course the larger the fish, the larger the roe. An increase in the length of a fish means a far greater increase

proportionately in its bulk. A bañgos a meter and a quarter in length, not counting the caudal fin, is, perhaps, at least twice as large as one three-fourths of a meter long. It seems probable that a bañgos never contains less than a million and a half eggs, and that a very large female may have in excess of 7,000,000 eggs. Bañgos average 3,000,000 eggs and can only be exceeded, if at all, by the cod, which has been known to have about 9,000,000 eggs.

I have not seen bañgos eggs after they have been spawned, but they seem to be demersible, and not of the floating type.

BAÑGOS FRY

The minute bañgos fry swim in vast shoals near the shore line of shallow sandy coasts and enter estuaries and tidal creeks. They come in with the advancing flood tide and go out with the ebb, and therefore are always surrounded by fresh, cool, but shallow water. A knowledge of this fact is fundamental to the successful culture of bañgos.

The capture of bañgos fry (kawag-kawag in Tagalog) is a very important industry. The flat sandy coasts of Balayan and Batangas Bays, Batangas Province, Luzon, furnish by far the largest quantity. The annual license fees for catching bañgos fry in Batangas Province during April, May, and June amount to about 100,000 pesos. The fry captured are shipped to Malabon and other points on Manila Bay, there being no bañgos ponds in Batangas Province.

Large quantities of bañgos fry are also caught and shipped to the Manila Bay bañgos growers from Mindoro, Marinduque, Tayabas, Sibuyan, Samar, Leyte, Tablas, Zambales, Pangasinan, La Union, and Ilocos Sur. Recently shipments are being made from Dumaguete, Oriental Negros. Most of the shipments are made in native sailing boats, but a good many are sent by truck to some railroad point or steamer. Bañgos fry are shipped from points as far as 800 kilometers from Manila.

The fry are caught in exceedingly fine-meshed nets, made of coarse sinamay (abacá cloth). Most of them are caught from the middle of April to the latter part of June, but they can sometimes be caught during the early part of July.

When captured, the fry are about 10 millimeters long and exceedingly slender. They are so small and transparent as to be nearly invisible. As soon as possible they are placed in low, wide-mouthed, pot-bellied, unglazed, earthenware jars (palayok

or palyok), some of which have a capacity of about 15 liters each, and others 30 liters. From about 1,500 to a little over 2,000 fry are placed in the 15-liter jar and 3,000 to 3,500 in the 30-liter jar. The jar is then covered with a piece of the base of a leaf stem, or petiole, from the areca, or betel-nut, palm. This is the most critical stage in the handling of bañgos. A little carelessness may ruin the whole stock in the jar. The jar should be kept filled with clean water so that the fry may move about freely, and should be handled carefully to avoid injuring the tender fry.

Vitality is the prime requisite for bañgos fry. They should be obtained from the nearest locality and placed in the nursery pond as soon as possible. Naturally those coming from far-away places are weakened by their long journey in confined quarters, often without change of water. The fry from Batangas are considered the best, but that is merely because they have been in captivity a short time. Around Manila Bay the best fry are those offered for sale the latter part of April and early part of May, since in June they are more likely to have been in the jars a good while.

At Manila the fry are usually purchased by men from Malabon who make a business of handling and rearing them and of supplying fishponds. Some of the owners of the large fishponds receive their supplies of fry direct from the Batangas fishermen.

When the fry arrive at the final destination the jars are carefully examined, all dead fry removed, and undesirable fishes rejected. Every effort should be made to see that the fry in each jar are of uniform size and vigor. Usually from 5 to 10 per cent in each jar die in transit, and in the jars that are shipped long distances the mortality reaches 25 per cent.

After the dealer has sorted the fry, the purchaser counts them. Manifestly, it would be impracticable to count the fry in all the jars, which sometimes number 500, so an average is usually taken by counting the contents of ten jars. In counting the fry a wide-mouthed china bowl is dipped into a jar and filled with water and fry. Then a clam shell is dipped into the china bowl and several fry are taken up in it. The counter calls out the number of fry in the clam shell and the number is checked by two tellers. This operation is repeated until all the fry in the jar have been counted. When all the fry in the selected jars have been counted the total number is divided by

10 and the result thus obtained is taken as the average number of fry in each jar. The average multiplied by the total number of jars gives the total number of fry in all the jars.

Fry are bought and sold by the ten thousand, or lacsa. The price varies at present (1927) from 15 to 50 pesos per ten thousand, according to the season and place. In general the price is lower in the vicinity of Malabon, and higher in Bulacan, Pampanga, and Bataan; it is also higher early in the season as the best fry are then available. The danger of heavy rainfall during the latter part of May and in June also reduces the price, since heavy rains cool the ponds and reduce the salinity of the water, weakening or even killing the fry.

Other fishes are often mixed with the fry in the jars; some are harmless, but many of them are injurious. The commonest fry found with schools of bañgos are bid-bid (*Elops hawaiiensis*), buan-buan (*Megalops cyprinoides*), several kinds of banak (*Mugil* and *Liza* sp.), and several kinds of gobies. Very young shrimps may also be found in the jar.

It is difficult to tell very young bid-bid and buan-buan from bañgos fry, for they are related and look much alike. Usually bid-bid and buan-buan are more active and a trifle larger. They should be removed at this stage, for they grow faster than the bañgos fry and soon begin to eat them. Young gobies are not as hard to detect, but are equally undesirable since they devour large quantities of bañgos fry.

Banak, or mullet, are not at all harmful, because they too are vegetable feeders; they are a valuable food of superior flavor. It is claimed that shrimps are not harmful and that they do not eat bañgos fry. This is very doubtful since certain kinds of shrimps of any size would certainly kill and eat all the fry they could catch. I believe that shrimps should be eliminated from the nursery pond as far as possible and also from ponds containing bañgos in the next stage of growth. After the fish has reached a length of from 40 to 50 millimeters, the presence of shrimps is not objectionable and indeed may be desirable, as they are readily salable at a good price. They act as scavengers, without interfering in any way with the bañgos or reducing the food supply.

THE BAÑGOS IN FRESH WATER

The bañgos often enters fresh-water rivers, and if there are large fresh-water lakes near sea-level it travels up stream to them. Lake Taal, Lake Naujan, and Lake Bato are the tem-

porary homes of many bañgos, but the water pollution and the large amount of river navigation attendant upon the growth of Manila, seem to prevent the bañgos from entering Laguna de Bay any more.

The bañgos remains in these lakes for several years, until it is two-thirds of a meter or more in length. Although these lakes are large, Lake Taal being somewhat more than 27 kilometers long and 20 kilometers wide, with a depth of nearly 200 meters in places, the bañgos never reaches sexual maturity here. Finally, when it feels the urge to return to the sea it starts down the outlet of the lake. At this stage it is called "lumulukso," a Tagalog word meaning "leaping," or "jumping," because of its astonishing jumps when in danger.

Very few of the bañgos in Lake Taal or Lake Naujan reach the sea, since the narrow outlet to each lake is completely closed by an immense, tightly woven, fish corral. Occasionally a fish leaps over the walls and gets away, but the number doing so is negligible.

THE BAÑGOS DOES NOT BREED IN CAPTIVITY

The bañgos only reaches sexual maturity in the open sea. Seunier, in his book on the marine fishponds of Batavia, states that in October, 1920, he was shown bañgos roe which was said to have been taken from a fish five years old, kept in a pond near Bangil, Java. Experiments by fishpond owners near Batavia, Java, and around Manila Bay have failed to produce sexually mature bañgos, even when the fish have been kept for as many as six years.

Fishponds are too small and the fish too crowded for the bañgos to reach its maturity rapidly. Other factors, such as the different chemical composition of the sea water and the different food obtained in the open sea, may also be necessary for its sexual development. The fact that it never reaches maturity in large lakes, such as Naujan and Taal, is very strong presumptive evidence that it will not do so in shallow artificial ponds, and that there are unknown factors essential to the development of the gonads.

SUPERSTITIONS ABOUT BAÑGOS FRY

According to the belief of old men in Batangas Province, bañgos fry originate in the following way: When the water is dried up and the soil exposed in swampy places in the interior, during the dry season, the ground is heated by the sun and

stirred into life. Light rain falling on it then causes the fry to form, and they are washed down by the river into the sea. As proof of their story the narrators point to the abundance of bañgos fry in the mouths of creeks and rivers.

In many parts of the Visayas and Luzon it is believed that bañgos, and also buan-buan and bid-bid, are generated spontaneously in fishponds. This is because the minute fry, entering with the flood tide, are overlooked.

ORIGIN OF THE FISHPOND INDUSTRY

The combination of desirable characters in the bañgos early attracted attention in many lands. Rapidity of growth, vegetarianism, absolute lack of cannibalism, the ease with which the fry could be secured in large numbers, the savory quality of the flesh, and other attractive qualities were factors not combined in any other fish of the same habitat.

It is impossible to say when men first constructed fishponds in the Indo-Pacific region, but the bañgos culture of to-day is the result of a gradual development over a period of many centuries.

The first fishponds for marine fishes were made by walling up the narrow entrance to a bay or inlet. An opening was left so that the fishes borne by the incoming tide could freely enter, after which it was closed by a gate which prevented their exit but allowed the interchange of water. Manifestly there was little control over the stocking of ponds by this method, and the results obtained were altogether a matter of chance.

BAÑGOS PONDS IN HAWAII, FORMOSA, AND JAVA

The greatest development of ponds of this character was in the Hawaiian Islands. The origin of these ponds is lost in antiquity, but some of them built two or three hundred years ago are still in use. However, the changes in population and crops have caused most of the ponds in use fifty or a hundred years ago to be turned to other uses or abandoned. Some of the Hawaiian ponds were very large, 200 hectares or more in a single inclosure. Most of them were made by building walls of lava across the narrow entrance to a bay and placing a sluice gate at a convenient opening. The principal fishes in the Hawaiian ponds were and still are mullet and bañgos.

The same principle was utilized in the construction of fishponds in Java, Madura, the Philippines, Formosa, and perhaps in other localities. As time went on various changes

were introduced. In the East Indies the extensive nipa swamps along the coasts were at first exploited solely for thatch and for the alcoholic beverage made from nipa sap. Later those in proximity to well-populated regions offered large areas ready to be converted into fishponds, merely by constructing a dam or dike to impound the water at high tide. Eventually, after the lapse of centuries, people in the more-advanced regions ceased to stock their ponds by chance. Instead, they adopted a set method of collecting the desired fry and put them into especially constructed ponds in place of those more or less naturally suited for the purpose.

Accordingly there came into existence around such favorable localities as Batavia and Surabaya, Java, Madura, Singapore, and Manila an enormous fishpond industry whose extent and importance are realized by few individuals not connected with the industry. Just when and where the construction of ponds from nipa swamps originated cannot be determined, but it was more than five hundred years ago.

The Dutch author C. Th. van Deventer, writing on the economic condition of the inland population of Java and Madura, records that the ancient Javanese laws punished "him who steals fish from a tambak," or artificial salt-water fishpond. These laws were codified about 1400 A. D., and of course fishponds must have existed before that time. The bañgos industry is evidently very ancient in Java.

BAÑGOS CULTURE IN THE PHILIPPINES

It is impossible to state when the construction of fishponds or the culture of bañgos began in the Philippines. It probably started on the shores of Manila Bay, around the city of Manila. There have also been bañgos ponds around Iloilo and on Mactan Island for a long time. For untold decades all fishponds in the Philippines were of a primitive type; the chance entrance of bañgos and other fishes was depended upon to stock them.

On Mactan Island opposite the city of Cebu this ancient style of pond continued till 1921. Mactan Island is a coral reef very little above high tide, and intersected by several salt-water tidal creeks. In places low dikes were constructed and at high tide the hollows among the rocks were filled with water, after which the gate was closed. Sometimes a good many bañgos entered, but their enemies also entered and not many bañgos survived. At the end of the season the pond was

drained, and if the owner obtained 25 to 40 pesos for his bañgos he thought he had done remarkably well.

About 1920, Dr. Pio Valencia, a Tagalog practicing medicine in Cebu, acquired an ancient fishpond on Mactan Island. He purchased a quantity of fry, stocked the pond, and at the close of the season sold the fish for 500 pesos, to the great astonishment of the local people. This result was obtained without any improvement of the pond and shows the difference between chance stocking and intelligent planting of bañgos fry. Later Doctor Valencia acquired more fishpond land and made extensive alterations and improvements until he has a fine modern plant.

Many of the fishponds in Iloilo Province and elsewhere in the Visayas are of the same ancient type, still being stocked by chance, the proprietors merely opening the gates at flood tide and allowing what will to enter. As a result, the Visayan fishponds contain a much more heterogenous assembly of fishes than the ponds around Manila Bay.

The Philippine bañgos fishpond industry has reached its highest development around Manila Bay, and the most skillful practice is in the region about Malabon, a town a short distance north of Manila. The largest ponds are found in Pampanga, Bulacan, and Bataan. The industry has likewise been developed in Iloilo and Capiz Provinces, and has been established in a minor way in La Union, Pangasinan, Zambales, Cebu, Oriental Negros, and other provinces.

VALUE OF PHILIPPINE BAÑGOS PONDS

The bañgos fishpond industry is really a major industry, and is a source of large revenue to the government of several provinces, even to some that have not a fishpond within the boundaries. Bulacan Province, with 3,193 hectares of land devoted to the fishpond industry, receives 118,000 pesos annually from taxes on its fishponds; while Batangas Province, with no fishpond within its boundaries, collects about 100,000 pesos from municipal licenses for catching bañgos fry. These fry are sold to growers about Manila.

It is impossible to state the exact amount of land devoted to fishponds about Manila Bay, but the approximate areas in the various provinces are as follows: Rizal Province, 3,193 hectares; Bulacan, 16,700; Pampanga, 14,200; Bataan, 4,000; Cavite, 659.

The market value of bañgos ponds about Manila Bay varies from 500 to 2,500 pesos per hectare. The value of a pond depends upon the distance to market; the distance to the open bay; the volume of water and its depth in the adjacent river or creek; the age of the pond; the quality of the soil in relation to the growth of lumut; the cleanliness of the pond, that is, its freedom from mud, grass, brush, etc.; and the liability to flooding by fresh water.

In general, bañgos ponds are more valuable in Malabon, Navotas, Obando, Bulacan, and Hagonoy and decrease in value as the distance from Manila increases. A conservative estimate of the value of the bañgos fishponds in the provinces listed above is over 45,000,000 pesos.

In Iloilo and Capiz Provinces there has been a rapid increase in the number of fishponds during the past few years and there are now about 900 hectares in operation, with an approximate value of 600,000 pesos. If the value of fishponds in Zambales, Pangasinan, La Union, Cebu, Oriental Negros, and other provinces is added, it is found that more than 46,000,000 pesos are invested in fishponds in the Philippine Islands.

The returns from bañgos ponds vary greatly and depend upon the management, the distance to market, the cost of transportation, and the weather conditions.

INCOME FROM BAÑGOS PONDS

The best fishponds, carefully managed, yield an annual income of 300 pesos per hectare. There are only a few owners, however, who get such good results. Some ponds bring in about 250 pesos per hectare; only ponds kept in very good condition do this well. Third-class ponds make a profit of 200 pesos a hectare each year. Ponds kept in good condition should do better than this, unless they are far from a good market and have poor transportation.

CONDITIONS AFFECTING THE SALINITY OF PONDS

The water in a bañgos pond varies greatly in its salinity, which is affected by the following:

Its nearness to open salt water, so that the stale water released may be replaced by, (*a*), sea water let in at high tide; (*b*), brackish or even fresh water entering from creeks, rivers, or canals.

Circulation within the system as the water is allowed to go from one pond to another.

Evaporation.
Rainfall.
Freshets or floods, as when fresh-water rivers overflow and burst the dikes separating them from the ponds.
The entrance of ground water or subterranean springs flowing in from below.
The entrance of artesian water; there are many artesian wells in the fishpond belt along the northern shore of Manila Bay.

During the dry season (March, April, and May) the salinity may rise to a high figure, but it drops greatly with the first heavy rains in June.

SELECTION OF A FISHPOND SITE

Salt-water fishponds in which bañgos are reared are called "plaisdaan" in Tagalog, "pocóc" in Pangasinan, "pocóc," "potót," and "lapát" in Ilocano, and "ponong" in Visayan. They vary in size from one-eighth of a hectare to 68 hectares as on the estate of Carlos Palanca, near Hagonoy, Bulacan. A system of fishponds under one management may contain hundreds of hectares, as the Ayala and the Carlos Palanca estates in Bulacan and Pampanga.

Large areas of swampland or tidal flats suitable for fishponds occur along the sea coast in many localities in the Philippines. In general, four factors are of prime importance in choosing a site; namely, the soil, the vegetation, the proximity of a deep tidal stream, and the market.

The soil.—Clay is the most desirable soil. It is not only retentive of water but is also best for the growth of the vegetation upon which bañgos feed. Sandy soil is, of course, not practicable, and soft mud is unfavorable to a good growth of algæ and injurious to the fish.

The vegetation.—The ideal land for a fishpond site is peat or tule land, as there is practically no clearing to do. As soon as the dikes and the sluice gates are built everything is ready for use. The commonest type of salt-water swamp in the Philippines and next best for fishpond purposes is nipa-swamp land. The nipa palm is easily cut off. It is not necessary to remove all the plants and stumps before using the land for a fishpond; in fact, it is often advisable to leave a few trees for shade. When the leaves are kept cut off and the terminal bud is destroyed the nipa plant soon dies. The stump rots quickly and is then easily removed.

Mangrove swamps are less desirable because the trees are larger, have hard wood, are more difficult to cut, are not easily

killed, and the removal of the stumps is much more laborious. Some mangrove trees may be left standing in a fishpond, but only a very few. Their spreading roots and sprouted fruits which are all ready to take root as soon as dropped are likely to be harmful to the pond.

The proximity of a deep tidal stream.—Great care should be taken that the fishpond is sufficiently near a deep tidal stream to insure a plentiful supply of salt or brackish water throughout the year, especially during the dry season. The ideal situation is in the angle between a tidal river and a tributary tidal creek. The water can then be taken in during high tide at the highest point on two sides of the plot and released at low tide at the point farthest down on the main stream. Land with fresh-water streams crossing it and land that is subject to flooding by fresh water during the rainy season should be avoided. If the site selected is by a very shallow tidal stream it often happens that during the dry season the bed of the stream becomes partially or even wholly dry. At such times the water in the pond may not be changed for some days, with harmful results to the bañgos.

The market.—It would be useless to have a bañgos pond without a market close by or else adequate cheap transportation to a good market. Some producers on Manila Bay use launches to take their fish to Manila. Others sell to middlemen or ship to Manila by truck or by small steamers. The bañgos grown at places some kilometers in the interior are shipped by truck to interior towns in Bulacan, Pampanga, and Tarlac, where there are no sea fish. On large coco and sugar plantations convenient to the sea bañgos ponds would be an excellent investment. Where salt water is not available, fresh-water ponds for the breeding and cultivation of carp and gurami should be a part of the central plant.

CONSTRUCTION AND ARRANGEMENT OF BAÑGOS PONDS

The cost of constructing a fishpond varies with—

The soil to be worked; as, clay, mud, or rock.
The topography, whether level, sloping, or undulating.
The vegetation present; nipa, mangrove, small bushes, cat-tails, sedges, lotus, or other herbaceous swamp plants.
The labor conditions in the locality.

After the site has been selected, the next step is to construct the main dike about the pond. After the location of the dike

has been marked off, the soil should be removed along the course to a depth of 30 to 60 centimeters, according to its character. Every stump, log, and stick of wood should be removed, for if left, they will rot sooner or later and ultimately let water escape.

The base of the dike should be not less than 4 to 5 meters wide, and it should rise well above the level of the highest tide or the height reached at any time by floods during the rainy season. The top of the dike should be a meter in width. Some well-made ponds have dikes of larger dimensions, wide enough at the top for a wagon or an automobile to pass along them, but such construction is ordinarily not necessary.

In the Manila Bay region where the soil is easily worked the laborers sometimes contract to build a section of dike 20 meters long, 3 meters wide at the base, and 1 meter 30 centimeters wide at the top for 20 pesos. When the soil is hard to work, such a section costs from 25 to 40 pesos. A much commoner method is to hire a gang of laborers and pay them by the square braza, the earth being excavated to a depth of 36 centimeters. The Spanish measure braza equals the English nautical fathom, or six feet. For each square braza, where the soil is easily worked and conditions are normal, the laborer receives 30 centavos. Where the ground is high, hummocky, or with large termite hills, the depth of the soil removed must be doubled or trippled as the case may be, with a corresponding increase in the cost of dike construction.

The soil for dikes is taken from the inside of the pond next to the embankment, thus forming a marginal trough, or ditch, deeper than the rest of the pond.

In building a dike the laborers work in two gangs. One group does the excavating, using a kind of handleless shovel, removes the soil in blocks, and places the blocks in a banca. The banca is then taken to where the work of dike building is proceeding. Here the second group of men passes the blocks of muddy soil from hand to hand till the last man sets them in place, as shown on Plate 3, figs. 2 and 3, and Plate 4, fig. 3. The tramping of the laborers in usually sufficient to solidify the dike, but if the soil is at all loose it should be well pounded to make the dike firm.

Where mangroves are abundant the construction of a pond is more expensive. The trees must be cut and their extensive root systems destroyed, all of which adds to the expense. On the other hand mangrove wood is esteemed as fuel, and the hard wood makes excellent charcoal. Greater care must be

taken in making the dikes in a mangrove swamp, and the stumps, roots, old logs, and limbs should all be removed.

Often the soil in a mangrove swamp is so full of half-decayed roots and twigs that the dike is easily set on fire during the dry season. Such a dike is also weaker than one of clay alone. The danger of fire is also a drawback to the selection of peat land for a fishpond.

A dike must be watched constantly to prevent breaks, to stop leaks or holes, to strengthen weak places, and to overcome the effects of settling. Burrowing animals of various kinds make holes in the dikes, through which water escapes with rapidity. During the rainy season rivers may become swollen and have swift currents which often undermine or cut through the dikes. Tides of unusual height must also be guarded against. In the Philippines, the highest tides are in January. A dike should be gone over thoroughly every year and repaired or strengthened. In mangrove or peat lands the dike will become more compact and therefore lower; and if a little more soil is added each year, in the course of a few years the dike will become solid and stronger than ever.

Where a fishpond is located beside a deep river or stream, or is exposed to the attacks of currents of either fresh or salt water in times of freshets or unusual high water, the dike can be further strengthened by various means. The ordinary way is to build the dike over a central wall of bamboo stakes; more rarely wooden piling is used. Sometimes a row or two of bamboo or hard-wood piling is placed along the exposed side of the dike, or it may be faced with planking.

Sometimes the dike is made stronger by planting mangrove trees along its top or along the exposed side. The spreading habit of the mangroves, and the dropping of their fruit seedlings in the fishpond are objectionable, but these can be watched carefully. In some places nipa is planted or left growing along the base of a dike next the river supplying water to the pond. It prevents floods from injuring the dike, and the sale of nipa leaves as thatch provides a small additional income. In Java, coco palms are planted on the dikes by some fishponds owners; these strengthen the embankments, give shade, and provide revenue. Mangroves are also frequently planted on the dikes of Javanese ponds. There are a few fishponds in the Philippines where cocos have been planted along the dikes.

A bañgos pond should never be deeper than the river beside it; its deepest part should always be slightly higher than

the stream at its outlet during ordinary low tide. The main part of the pond may be very shallow, the water over most of it with a depth of perhaps half a meter. Around the margins where the earth was removed to form the dikes it is, of course, deeper. In large ponds two more ditches are dug, each one connecting the centers of opposite sides of the rectangle and intersecting each other at right angles. All these ditches should be made with the bottom sloped so that all the water will drain readily to the outlet of the pond. Ponds of great extent may include part of a creek or even several small creeks, in which the water may be two to several times deeper than elsewhere. Such channels are beneficial in providing cool areas for the fish to lie in when not feeding and are convenient when it is necessary to do repair work or clean a pond, as the fish can retire to them when the rest of the pond is partially or wholly bare.

A bañgos pond is of necessity divided into several compartments or made up of several connecting ponds which are operated as a unit. A fishpond should be divided into not less than four smaller ponds, or compartments, and as many more may be made in large ponds as are found necessary. These ponds naturally vary in size and depth, since they must accommodate fish of different sizes and are used for different purposes. One of the ponds in the system should be very much larger than any of the others. Where the total area is small and there are but four or five divisions in all, the largest division should be as large as all the rest taken together. In a fishpond system of any size it is necessary to have a small catching pond, into which the fish are led when they are to be caught for market.

As bañgos ponds are constructed on tide flats, where the land is uniform in topography, they are usually rectangular in shape. There may be exceptions to this caused by the meandering of bordering creeks from which the supply of water comes.

The partition dikes, or those between the small ponds, are low, usually narrow, and are never as strongly built as those around the outside of the system. The small ones may be 25 centimeters wide at the pond level and hardly wide enough at the top to provide safe footing; the large ones may be a meter or more at the water level and a meter wide at the top. When they are temporary the width makes little difference, but if they are to be permanent they should be strong enough to with-

stand ordinary wear and tear and to permit free passage along their tops.

Gateways are, of course, necessary in the dike, to control the intake and outlet of water. Most fishponds are built with but one main sluice gate, but the best method is to have a gateway

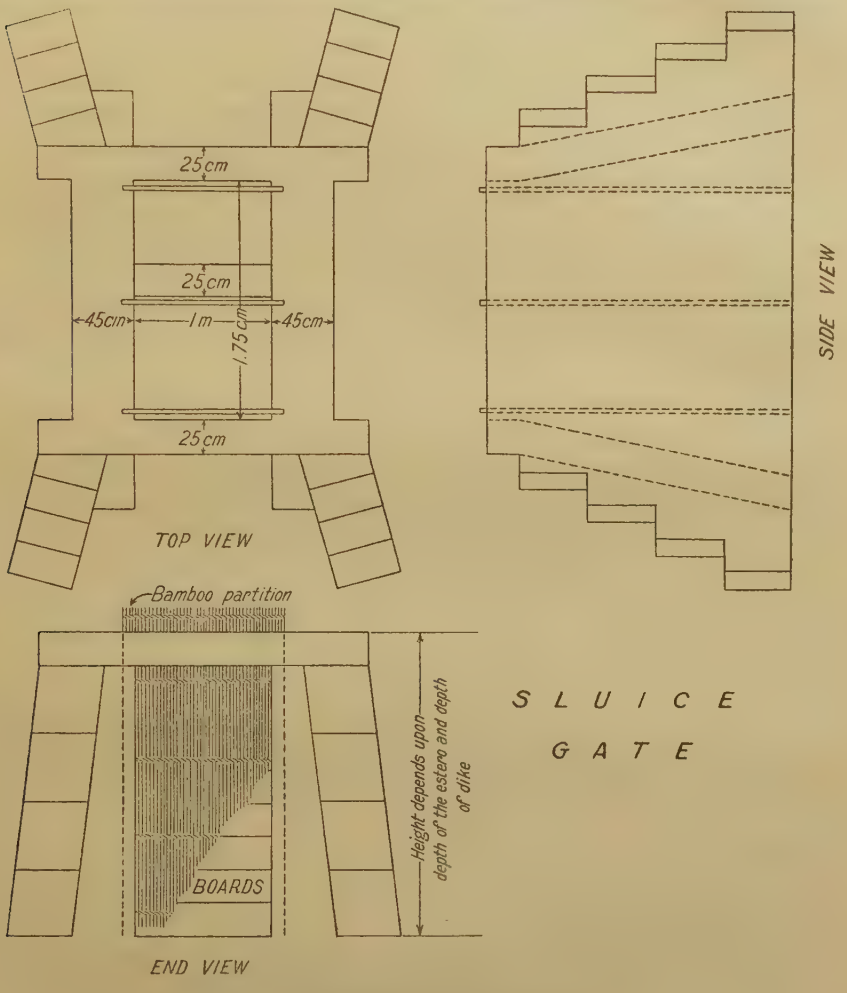


Fig. 1. Plan and elevation of fishpond sluice gate.

at the highest point or place farthest away from the sea, where water may be taken in at high tide, and another sluice gate at the lowest point, so that the pond may be easily drained at low tide.

The main gate or gates should be constructed of concrete. Formerly they were made of stone, and cement, brick, or even

of wood, but the superior merit of concrete construction is gradually forcing out all other methods. In some regions the main gates are still simple in construction and made of wood, as a rule. The main sluice gate should be of ample dimensions, with a large base. If the base is too small the gate will settle unevenly in time, cracks may form, and the gate become practically useless. If the ground is very soft or lacks uniformity it is often necessary to drive it full of bamboo or hardwood piling and place over this a kind of bamboo raft which supports the concrete foundation. The opening for the passage of water in a sluice gate is about 1 meter. The cost of such a concrete sluice gate varies from 700 to 900 pesos. Its general appearance is well shown on Plate 4, fig. 2, and Plate 13, fig. 2.

The main sluice gate should be so made that three sliding doors or gates, moving up and down, may be used. When they are all in place they inclose two spaces within the gate. The principal door is in the middle and is composed of closely-fitting slabs or boards of very durable wood placed edge to edge. These may be added or removed to regulate the flow of water or to stop it altogether. At the entrance and the exit of the sluice gate are sliding doors made of closely woven split bamboo. These doors allow water to pass through freely but prevent more or less successfully the entrance of undesirable fishes, crabs, water snakes, and other aquatic enemies, and prevent the escape of bangos. However, shrimps are also considered so important a crop that pond caretakers encourage their entrance into the ponds.

In addition to the main sluice gate or gates, it is necessary in a good fishpond system to have small sluice gates of simple construction placed here and there to allow water and fish to pass from one pond to another. These secondary gates are usually of wooden construction and rarely have more than one door. They are small compared with the main gate and are usually not more than two-thirds of a meter in breadth, and very little if any longer than the width of the partition in which they are placed. They vary from temporary ones costing but a few pesos, to permanent ones that may cost 500 pesos or more. Sometimes some of the ponds are connected by hollow logs set in the dikes. This is a cheap way, but control is difficult. Some people even make ponds entirely separate

from each other. This may do for some fresh-water fishes, but is poor practice in bañgos ponds. In a first-class bañgos system all the ponds are connected so that water can be let into or drawn from any pond desired.

After the dikes, cross dikes, sluice gates, and other gates have been constructed and the pond system is completed, there are expenses not yet mentioned. There must be a caretaker close at hand at all times.

The caretaker must have a house of some sort. It is usually placed near the main sluice gate. The house may be a bamboo and nipa shed costing a few pesos or a well-built, modern cottage costing several hundred pesos. In many places an artesian well is necessary to provide drinking water. The cost of drilling a well is from 150 to 200 pesos. The usual wage received by the caretaker is 40 pesos a month, and often a liter of kerosene a week in addition. Some owners pay as little as 150 pesos a year; needless to say they do not get first-class service. Large systems of fishponds, ranging from 200 to 800 hectares in extent, pay good salaries to the resident manager, up to 350 pesos a month including a good house, light, and a motor boat for inspection trips. A fair average salary for the foreman in charge of a fishpond system of moderate size, 15 to 60 hectares, is 45 pesos a month.

Laborers must be employed to inspect and repair the dikes; to destroy snakes, crabs, and other vermin; to kill or scare away fish-eating birds; and to assist in transfering young fish and catching those marketable, changing water in the ponds, repairing nets, and the rest of the daily routine. Wages are from 1 to 1.50 pesos a day, depending upon the locality; near Manila they are higher, and in outlying provinces they may be much lower.

Several small bancas and one or more large ones will be needed for transportation along the river and in the canals and ponds. The number will vary with the size of the establishment and the number of workmen. Large drag nets, or seines, will be needed for catching marketable fish. Small fine-meshed nets (panagap) are needed to catch hatirin; these nets are from 6 to 8 meters long and 3 or 4 meters wide. Large long-handled dip nets are used for many purposes, and several of the square dip nets (bitinan) will be needed when hatirin are caught.

Small fine-meshed baklad are necessary for catching shrimps, or ulang and sugpo, and various kinds of crabs such as alimañgo and alimasag. All told these will cost from 100 to 200 pesos.

A large fish-pond system will need a motor boat to carry the fish to market, bring supplies, and make inspections. With a motor boat the owner can market his fish without delay and in first-class condition.

FISHPONDS IN THE VISAYAS

In general, fishpond construction in the Visayas is antiquated and much behind the standards set by the fishpond owners of Malabon, Bulacan, and Pampanga. There are some notable exceptions to this, particularly around Molo, Dumangas, Barotac Nuevo, and Banate, in Iloilo Province, and on Mactan Island.

A great deal of interest has been shown recently in the construction of fishponds in the extensive swamps and marshlands of Panay. Unfortunately few of the persons interested are informed about the proper methods of constructing ponds, raising bañgos, or of choosing a suitable location.

Not every swamp is suitable for the successful operation of fishponds. Owing to their general topography, many swamps are distinctly unfavorable to the development of fishponds. In the Visayas tidal swamps are often subject to one or both of the following disadvantages: (*a*) Exposure to the open sea so that the dikes are subject to erosion from strong waves, which damage them seriously and sometimes destroy them; (*b*) hills are so close to the ponds that the flood and rush of water from heavy rains washes out or damages the dikes, and the ponds are flooded so that their salinity is reduced too much. Both these disadvantages must be avoided.

The salt-marshlands of the Visayas are in general of three types; namely, rocky, nipa, and mangrove. The nipa swamps are by far the best adapted for conversion into fishponds, especially when located in the delta of a river. The soil in a nipa swamp is always retentive of moisture and favorable to the construction of fishponds.

The mangrove swamps are densely covered with hardwood trees, which are expensive to cut off, the stumps and extensive root systems of which are difficult and expensive to remove. Of course the sale of firewood and charcoal provides some return, but this will not equal the cost of removing the stumps.

In some instances the mangrove swamps have a soil of coral sand, which is very deficient in clay. In such places fishpond dikes are very easily washed away by waves or by freshets, and may be seriously injured even by high wind. Such swamps should be avoided for fishpond sites.

In some places, as on Mactan Island and the coast of Ilocos Norte, the swamps are very rocky, being really nothing but a slightly elevated ancient coral reef. Where the general level of a rocky swamp is but little above high tide, with many portions covered by salt water at ordinary low tide, the difficulties of making a good pond are not too great, provided there is a sufficiency of good clayey or impermeable soil. Unless there is enough soil to make good substantial dikes the loss of water by leakage becomes too great for successful operation. Where large rocks and outcropping coral ledges are numerous, blasting is often necessary to connect the intervening pools and get sufficient pond area of the proper depth.

In both mangrove and rocky swamps it requires much well-supervised labor and ample funds to construct a fishpond of fairly uniform depth, avoiding extreme depth or shallowness, with satisfactory dikes and gates.

Most fishponds in the Visayas are defective in the following particulars: (*a*) The nursery ponds are not well arranged and properly maintained, and in many cases are altogether lacking; (*b*) when they are present, small ponds are often not provided for the young fish when they are released from the nursery; (*c*) too little care is taken to free the fry from enemies such as bid-bid and buan-buan, and not enough pains are taken in preventing enemies from entering the ponds with the tides when water is changed; (*d*) a proper growth of lab-lab is usually lacking, so that a high percentage of kawag-kawag starves to death. In many cases ponds in mangrove swamps are made by merely damming a creek. Part of the inclosure is usually too deep for the successful growth of lumut, and other portions are too shallow. In some places ponds are located one behind another, each damming a portion of a small tidal river. This is poor practice, since only the outer one has free access to water, the inner ones being able to change water only as it is released by the one in front of them.

THE NURSERY POND

The most important division of a fishpond, and usually the smallest, is the nursery pond, in which the fry are placed.

This may be of any size, from a compartment 10 by 15 meters to a pond more than a hectare in area, according to the number of fry necessary to supply the ponds later. In most nurseries a small compartment (pabiayan) is made at one corner of the large inclosure. It may vary in size from 5 by 5 meters to 40 by 40 meters, according to the number of fry, and has an opening about 1 meter wide which leads into the nursery proper. Tubes are also placed in the dividing wall so that water may pass back and forth freely. A galao is placed over the inner end of each tube, and the other end is closed with a very fine screen, which effectively prevents all bañgos fry from escaping.

A galao is an elongate, fine-meshed, woven-bamboo basket, shaped like certain types of bobo, or fish traps. It is 1 meter long, 28 centimeters wide at the base, bulging out at the middle to 35 centimeters, and 18 centimeters wide at the upper end.

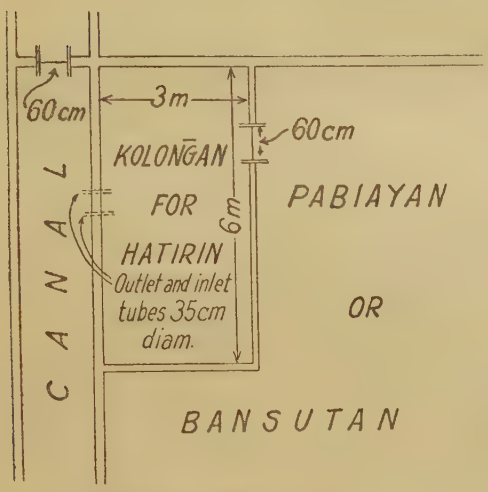
In large fishpond systems the nursery has a number of small inclosures, or pabiayan. Every other pabiayan is used for slightly older fry and is called a "bansutan." When a given batch of fry has been distributed in the pabiayan the fry are kept there a short time, about two or three weeks, or until another lot of fry is received. By that time they should have grown from 10 millimeters to 30 or 35 millimeters in length. Then the first batch is moved over from the pabiayan to the bansutan, and the new consignment is divided among the pabiayan just vacated. In this way the fry of a given size are kept to themselves.

The preparation of the nursery is a tedious, delicate, but very important task since upon its condition depends the success or failure of the fishpond as a whole. Not only are bañgos fry very delicate, susceptible to variations of heat and cold, but their food is entirely different from that of the older fish. Whereas bañgos kept in ponds feed largely or entirely on filamentous green algæ and the leaves of submerged flowering plants, the fry feed upon lab-lab.

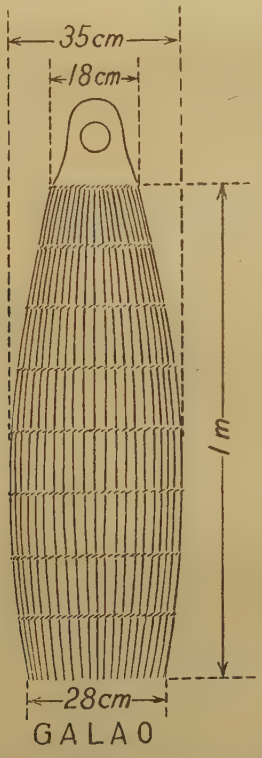
LAB-LAB

Lab-lab is the Tagalog name for the plant complex that under certain conditions forms a crust or mat upon the floor of the nursery pond.

A microscopic examination of lab-lab shows it to be largely composed of unicellular, colonial, and filamentous blue-green



Portion of a nursery showing parts in detail



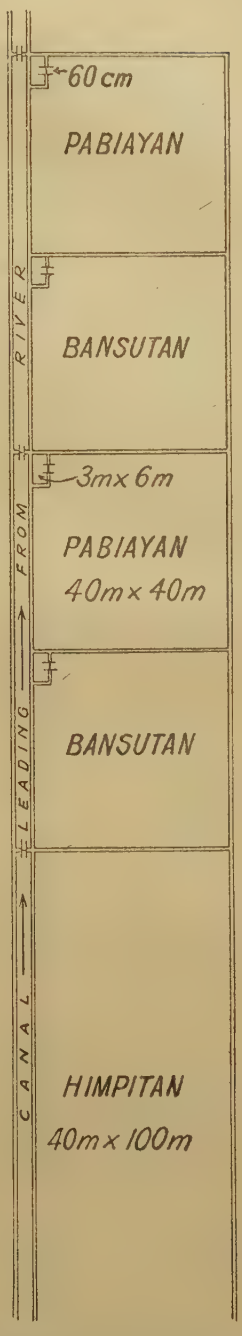


FIG. 2. Plan of a bañgos nursery pond, at Dampalit Barrio, Malabon, Rizal Province, Luzon. This pond is used for salt making during the dry season. Below, a fish trap (galao).

FIG. 3. Plan of a part of a 20-hectare fishpond system with six 3-hectare catching ponds (kaloañgan). Paombong, Bulacan Province, Luzon.

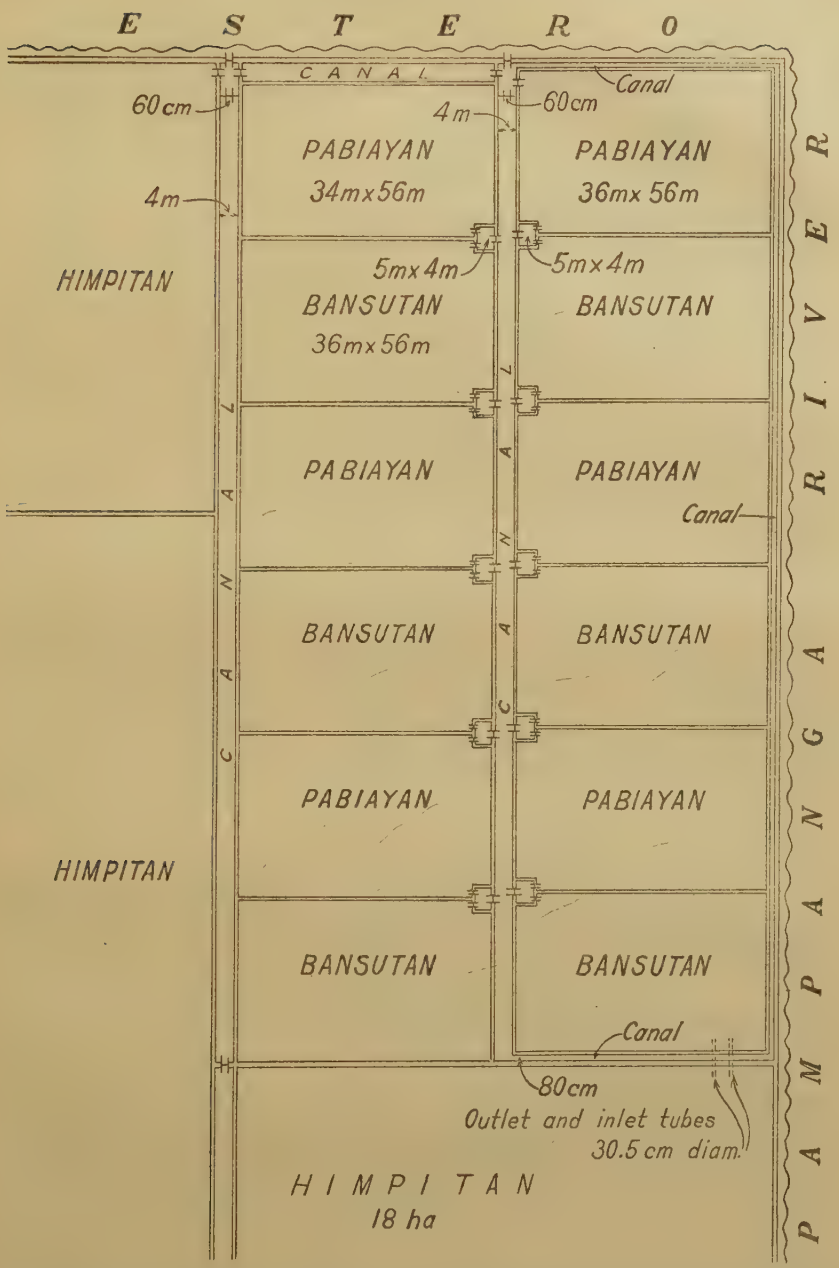


FIG. 4. Plan of a part of a 600-hectare fishpond system. The nursery will cost 4,000 pesos and will hold 1,500,000 bangos fry (kawag-kawag). Ayala and Company, Macabebe, Pampanga Province, Luzon.

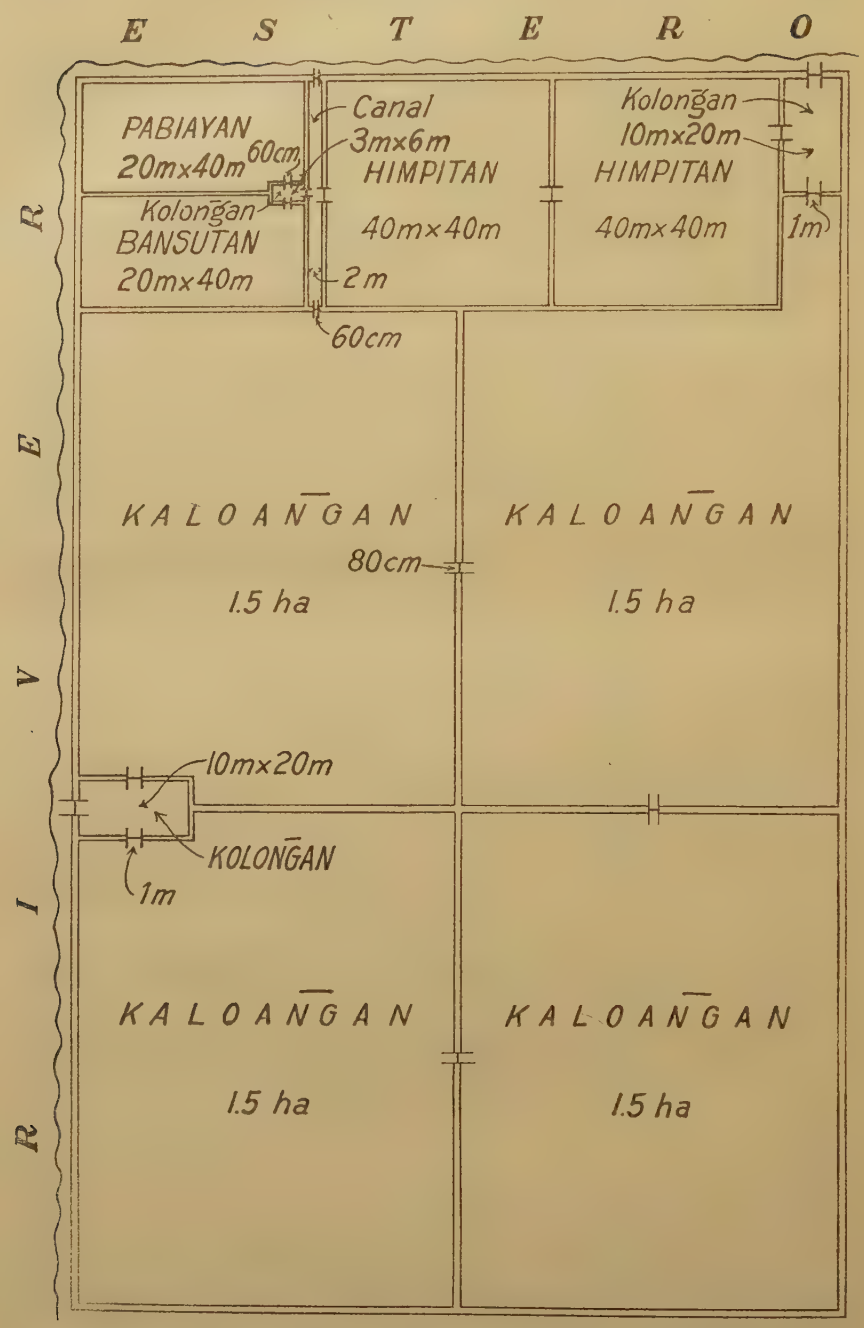


FIG. 5. Plan of an 8-hectare fishpond system, showing the various parts.

algæ, mostly small species of Oscillatoriaceæ; it also contains a great variety of diatoms, bacteria, some unicellular green algæ, and a small proportion of very fine threads of Chlorophyceæ, or filamentous green algæ, such as *Cladophora, Spirogyra,* and *Chaetomorpha.* It also contains many Protozoa, minute worms, and small Crustacea.

The nursery pond is first drained, cleaned, and allowed to dry for at least two weeks. During this time all enemies of bañgos fry should be removed or killed. When the pond is sufficiently dry, water is turned in to a depth of 10 centimeters. After three or four days a growth of lab-lab will be seen on the bottom of the nursery pond. This increases very rapidly until it forms a dense thick mat over the entire floor. The water is gradually increased in depth to approximately 25 centimeters. If the water is any deeper than this, the fry become exhausted diving to feed on the lab-lab attached to the bottom. The water in the nursery pond should be kept clean and fresh, and the pond should be so constructed that the water can be changed rapidly. It should be changed at every tide or at least once a day.

As the water is deepened in the nursery great patches of lab-lab are buoyed up and float to the surface, carrying more or less soil with them. The quantity of lab-lab detached and floating varies with the depth of the water and its temperature.

CARE OF THE BAÑGOS FRY

The nursery pond should be all ready to be occupied when the jars of fry are delivered. To place the fry in the nursery, a jar is set in the water, tilted to one side, and the pond water allowed to flow gently into the jar. The jar is then slowly and carefully turned over until the fry can swim out.

The temperature of the water in the nursery pond is a matter of great importance. It must be cool and should be the same temperature, as nearly as possible, as the water in the jar. As the jars are made of unglazed earthenware the constant evaporation of water through their pores keeps the water inside them cool. Late afternoon or early morning is the best time for putting fry in a pond.

The first three or four days that the fry are in the nursery constitute the most critical period. If heavy rains fall during that time the surface temperature of the pond water drops very suddenly while the saltier water near the bottom is much warmer. This condition makes the fry sick and at such times

the mortality may be as high as 80 per cent. When the rainfall is heavy, pieces of floating lab-lab are dashed about or are carried under by the falling water, crushing many of the fry. Overstocking the nursery pond is the commonest mistake made. One hectare of pabiayan with a good growth of lab-lab can support 300,000 bañgos fry. The bansutan should not have more than half or two-thirds as many, as the fish are larger. More than this number will deprive them of the necessary space in which to move about and will soon exhaust the lab-lab. If the fry are too crowded many of them die.

The nursery pond must be carefully watched to prevent the entrance of enemies. Water snakes (*Chersydrus granulatus*), calabucab in Tagalog, and various kinds of sea-snakes (species of *Disteira* and *Lapemis*), malabasan in Tagalog, commit great depredations. The presence of certain fishes is also a serious matter. Apahap (*Lates calcarifer*), bid-bid (*Elops hawaiiensis*), biang puti (*Glossogobius giurus*), talimosak (*Preiophthalmus barbarus*), tamindak in Visayan, and where the water is only slightly brackish dalag (*Ophicephalus striatus*) and liwalo or puyo (*Anabas scandens*), devour the helpless fry wholesale. A few snakes and a shoal of any of the above fishes will soon devour every young bañgos in the nursery.

Some birds, such as herons and kingfishers, are also very serious enemies of bañgos fry. Fishhawks and eagles are fond of bañgos and will catch and eat the marketable fish. It is often necessary to post a watchman armed with a shotgun to kill or scare off the birds, especially around the newly established fishponds.

Many fishpond owners, especially around Malabon, Navotas, and Obando, use their ponds exclusively for nursery purposes. They carry the fry through the critical early stages and sell them later to growers whose ponds are in less-favorable localities in Pampanga and Bataan Provinces.

If the conditions in the nursery pond are all favorable, the bañgos fry grow rapidly and should be 40 to 50 millimeters in length in from four to six weeks. After they are 35 millimeters or more long they are called "hatirin," or "pawalain" in some parts of Bulacan, and are ready to be transferred to larger ponds. Hatirin still feed somewhat upon lab-lab but begin to feed upon lumut or filamentous green algæ, and as they grow cease gradually to eat lab-lab.

One of the most-marked characteristics of bañgos is their instinct to swim against a current. Advantage is taken of this

in moving them, as without this habit it would be difficult to catch them when small and delicate, without injuring many. When water is admitted through the sluice gate at high tide bañgos, no matter how small, meet the inflowing current and crowd against one another in it, frequently jumping in the air against the flow of water.

A large fine-meshed net (panagap), 6 or 8 meters long and 3 or 4 meters wide, but narrower at the bottom than the top, is used to surround the fish after they are gathered in the current. The hatirin are now scooped up in two large square dip nets (bitinan), half the quantity of young fish in each. The fish are not lifted from the water, but the bag of the dip net is kept down so that the fish are always under the water. Each dip net is supported by a bambooo pole at each corner, and the poles are stood up vertically in the pond.

The contents of each dip net are again divided in the same way between two dip nets, and this process is continued until the number left can be counted easily, care being taken to keep the fish under the surface of the water. The total number of fish is obtained by doubling the count in the last net, and then doubling for each division made before.

The fish can be very easily transferred to another division of the same pond. One man takes hold of each pole, and the others carry the net along keeping its bag down so that the fish are always under water.

When the hatirin have to be transported longer distances a large clean banca is used. The boat is partly filled with clear salt water, and the fish are placed in it. A screened hole in the banca provides circulation of water, and men bail constantly to keep the boat from sinking. If the distance is very great the banca is towed by a motor boat. The transfer of hatirin should be done during the coolest part of the day or, if possible, at night.

Sometimes large hatirin are caught by draining the pond until there is no water left except in the ditch through the center and around the margin. The hatirin are then dipped up in a fine-meshed net.

The current price of hatirin is from 65 to 125 pesos a lacsa, depending upon their size and vitality, and the distance to be transported. They are shipped during May, June, July, and August.

A hectare in a first-class pond used as a himpitan will carry 10,000 hatirin for a short time until the large pond is ready.

GROWING LUMUT, OR ALGÆ

For convenience, the word "lumut," widespread in the Malay languages, will here be used as a synonym for "algæ."

Before hatirin are placed in a pond it should be drained and left dry for from three days to a week, depending upon the weather. All snakes, mud skippers, and other enemies should be destroyed. Then the water should be turned in to a depth of about 10 centimeters, which will start lumut growing all over the bottom of the pond, in small rounded bunchy patches. As the lumut gets larger, the depth of the water is gradually increased. The little hatirin nibble away at the young lumut, but if the proportion of fish is correct there will be sufficient feed for a time. In the meantime the large pond or ponds should be prepared in the same way with a fine growth of lumut, for hatirin are only kept in the first small-sized pond until the large one is ready for them.

In some places where the soil conditions are not very favorable, it may be necessary to grow lumut by transplanting. First the pond is drained and well cleaned as previously described. Then water is turned in again to a depth of 10 centimeters and clumps of lumut are planted. As soon as new growth begins, the depth of water in the pond is steadily increased until the normal depth is reached. By that time there should be sufficient growth of lumut so that fish may be turned into the pond.

Under favorable conditions the growth of lumut may be so luxuriant that some of it must be removed to give the fish room to move about freely. The same result is obtained by putting in lines of stakes and crowding the lumut behind them, thus making lanes of clear water in which the fish can swim.

On the other hand, during the rainy season the mud carried into the pond and the reduction of the salinity of the water by prolonged heavy rains seriously check the growth of lumut. The mud is deposited upon the young algæ springing up on the bottom and checks its growth or kills it. An excessive amount of fresh water coming in contact with algæ in salt-water ponds may plasmolyze the filaments and destroy the plants. When this happens on a large scale the ignorant laborer sometimes says that fresh water kills the bañgos. What really happens in such cases is that the fish starve to death because the algæ have been killed by the fresh water.

In ponds subject to flooding by fresh water or where the salinity becomes much reduced, especially during the rainy season,

there is sometimes difficulty in keeping down the growth of grass in the pond itself. When other means fail the bottom of the pond where the grass grows is scraped off to a depth of about 10 centimeters. The mass of grass and roots is then thrown into the river, to be carried away.

The fish are too crowded in the hatirin pond to make the rapid growth that comes later in the large pond. The hatirin are usually kept two or three months in the pond to which they were first transferred. They are then 75 to 100 millimeters in length and are called "garoñgin." In some parts of Bulacan they are called "bansut."

GAROÑGIN

Some people keep garoñgin in small ponds with an ample supply of fresh sea water but with very little lumut for six or seven months. They then sell them at a high price to people who wish to stock their ponds and produce marketable bañgos out of the usual season.

Where fishponds are easily cleaned and there is little or no danger of the fish being eaten, the hatirin are turned at once into the large pond, called in Tagalog "kaloañgan," or "spacious." The other method is to hold the hatirin in a small pond, called "himpitan," or "small space," as already described, until the hatirin are large enough to be in no danger from ordinary enemies.

STOCKING THE LARGE BAÑGOS POND

The number of fish per hectare in ponds stocked for market depends upon the condition of the pond. The usual practice is to overstock. Carefull growers when making the final allotment usually put in 1,000 hatirin for each hectare of pond in good condition. A pond in excellent condition where everything is favorable, as the Ayala ponds at Macabebe, Pampanga, can carry from 1,500 to 2,000 hatirin or garoñgin per hectare till ready for market. We believe that as a rule beginners will obtain better results with a smaller number and therefore recommend that in making the final distribution 800 to 1,000 hatirin be allowed for each hectare of pond with a luxuriant growth of lumut. Then if a grower finds by experience that his pond can safely carry more he can gradually add more young fish until he finds the limit his pond can feed.

Heavy losses or even failure result from overstocking. Many owners know that their pond will not support the large number of fish that they place in it. They say many are going to die, and they have the foolish notion that if they put in a great many they will have more left than if they put in a smaller number. Accordingly they put in five, six, eight, or more thousand young fish for each hectare and of course they die wholesale. There have been cases where unthinking people have put as many as 30,000 hatirin in a hectare. Of course, the more they put in the higher the percentage of deaths. Even if a pond is only slightly overstocked the supply of lumut is soon exhausted, and the undernourished fish crowd one another so that they do not have room to exercise and develop properly.

Sometimes a fishpond owner attempts to supply the lack of food in his pond by buying lumut. As bañgos are voracious feeders it is difficult to buy enough lumut to feed them, and the cost at 5 pesos a banca load may soon exceed the normal profit. Others who have overstocked or whose ponds are without a good growth of lumut are compelled to sell their bañgos long before they are large enough to bring a profitable price.

Garoñgin 10 centimeters long should reach marketable size in from two to three months after being turned into a large fishpond with all the conditions favorable. Garoñgin can be transferred from pond to pond in the manner already described for hatirin, but usually they are handled in a different way.

The garoñgin are led into a small catching pond by causing a stream of water to flow from it. Naturally they swim against the current, and as soon as they have passed in the gates are closed. A long net or mat of split bamboo, about 12 meters long and 1.5 meters wide, is used to surround the garoñgin in a semicircle or horse-shoe form inclosing the gate. This semicircular shape is called a "garong" and the name "garoñgin" for the fish inclosed is derived from it. The garoñgin are taken up from the garong with dip nets and counted as they are turned loose in the final pond.

There is no fixed time for putting hatirin or garoñgin in the final stock pond. Whenever one has a pond in proper condition and can get strong healthy hatirin or garoñgin is the time to plant. The best time to plant is during the dry season, as weather conditions are more favorable then and it is easier to keep enemies in check.

FOODS PLANTS OF BAÑGOS

The diet of bañgos under normal fishpond conditions is almost exclusively composed of filamentous green algæ or lumut, belonging to the Chlorophyceæ. As previously explained, the fry feed at first upon lab-lab but gradually change their feeding habits until they feed only on lumut.

The principal algæ growing in the bañgos ponds about Manila Bay are various species belonging to the genera *Cladophora, Enteromorpha, Spirogyra,* and *Vaucheria.*

The blackish green patches or masses of *Enteromorpha* are conspicuously different in color and general appearance from *Cladophora* or *Spirogyra.* These algæ may form a nearly solid growth of green to yellowish green, matted and more or less floating entanglements, while *Vaucheria* creeps over the bottom in dense felted masses which rise only part way to the surface. *Spirogyra* is exceedingly slippery to the touch and in this respect contrasts strongly with *Voucheria,* which feels like coarse wet cotton.

Where conditions are favorable these algæ grow in dense masses over large areas, frequently almost completely filling the pond.

Various hydrophitic flowering plants also occur in bañgos ponds, and the general name "digman" is applied to all of them. *Ruppia graminea* var. *rostrata* Agardh, *Nejas graminea* Delile, *Halophila beccarii* Aschers, *Halophila ovata* Gaudichaud, and *Thalassia hemprichii* (Ehrenberg) Aschers are found in fishponds, and all are included under the name "digman." Some species of *Ruppia* do well in sea water, but most kinds of digman thrive best in the rainy season when the salinity of the ponds is reduced. Sometimes the growth of digman becomes so luxuriant during the rainy season, especially in July and August, that there is hardly room left for the fish and it becomes necessary to have some pulled out by the roots. *Halophila beccarii* occurs only in salt-water ponds, sometimes entirely covering the bottom, rooting in and creeping over the mud and remaining entirely submerged.

When the salinity of a pond has been very greatly reduced duckweed, or lia, *Lemna paucicostata* Hegelmaier, may appear and increase till it nearly covers the surface of the pond. The presence of *Lemna* under such conditions is an indication that the pond is not in good condition, and that dalag are probably

present. The pond should be restored to good condition by having the salinity raised to normal. The *Lemna* itself is not harmful and bañgos eat its roots greedily.

When bañgos are sick they usually scatter, instead of swimming in groups or small schools. They become sluggish, whereas healthy bañgos are noticeable for their quick movements. If the body looks thin, the head too large for the body, and the base of the pectoral fin becomes whitish, they are not getting enough to eat. At such times *Lemna* is given them as "medicine," but all the medicine they need is plenty of lumut or digman. When the pond cannot supply enough food, some people soak tikitiki (rice bran) over night till it sticks together, then put it on the bottom of the pond in small mounds for the bañgos to eat. Others throw horse manure into the pond and say the fish like to eat it. However, the fish are so hungry they will eat anything. When there is not enough lumut in a pond bañgos will eat all the grass projecting from the dikes into the water, and will even stick their heads out of the water to reach grass on the bank.

ONE CROP OR TWO CROPS A YEAR

Harvest time in bañgos ponds varies widely according to the management and also the locality. There are two plans in general use; namely, harvesting once a year and harvesting twice a year. To say that the bañgos are marketed but once a year is a misstatement, since under this system they are really harvested from the end of May to the close of the rainy season in September. When the fish are taken from a pond it is drained and a new growth of lumut started unless the pond already has a luxuriant growth of algæ. It is then promptly restocked with the requisite number of hatirin or garoñgin, so that very little time is lost from the use of the pond. The bañgos harvested under this method weigh from 400 to 600 grams, with an average of 500 grams, and sell at from 25 to 42 centavos each, according to the state of the market.

Occasionally a few bañgos escape when the rest are harvested and remain uncaught for another year. By the end of the second year they will weigh between 1 and 2 kilograms. Such bañgos are called "laón."

When the owner follows the method of harvesting bañgos twice a year hatirin are placed in the pond during May or June and marketed from the end of September through the month of October. Then the pond is drained, the ground freshly pre-

pared, and the pond restocked with garoñgin which are harvested in April and May. The bañgos reared under this method should reach a weight of 300 to 500 grams and sell for 20 to 35 centavos each.

Under this plan the owner should keep a himpitan well stocked at all times with hatirin or garoñgin, ready to place in large empty ponds whenever they have been cleaned and have enough algæ to support the proper number of fish. Some owners keep two sizes of bañgos in a given pond. Then when the larger ones are marketed a coarse-meshed net is used which permits the smaller ones to escape. After those of large size have been removed hatirin or garoñgin are added to take the place of those marketed, those that escaped the net being sold in their turn a few months later. This operation can be continued as long as the pond remains clean and the algæ continue to grow luxuriantly. Whenever foul mud accumulates on the bottom of the pond or algæ fail to grow properly the pond should be drained and sunned, and a fresh growth started as previously described.

Each method of growing and marketing bañgos has advantages, and a fishpond owner must determine for himself which is better under the conditions in his locality. In general the better plan is the one that keeps down overhead expenses and labor costs without unduly reducing the income.

When bañgos are harvested but once a year they naturally bring a higher price because they are larger than those four to six months younger. Labor and transportation costs are also much less under this plan. In spite of these facts, harvesting the bañgos twice a year is the more profitable method if the pond is first class in every way and marketing conditions are favorable. Another point to consider is the greater salability of small bañgos. The common people are the chief users of bañgos, and their purchasing power is low; until their economic status is much improved it will continue to be easier to sell three small fish than a larger one costing twice as much as one of the others.

The weight that a bañgos should attain within a given length of time is unknown, and there are many factors that help determine the rate of growth. Some of the more important of these are the following:

The rate of renewal of the pond water, or the time elapsing between changing the stale water with clear fresh tidal water of the proper salinity.

The circulation of water within the pond system.
The amount of rainfall.
Sudden variations in salinity.
The character of the soil forming the bottom of the pond.
The kind, the quality, and the quantity of food available per fish.
The size and the depth of the stock ponds.
The number of fish to the hectare.
The number of bubuntis or other fishes living upon the same kind of food as that eaten by bañgos.

THE CATCHING POND, OR KOLOÑGAN

As previously stated, a large fishpond system should have a small division where the marketable fish may be caught. In systems containing only a few hectares any of the smaller divisions may be used for this purpose, or a nursery pond may serve as a koloñgan if it is without fry.

The koloñgan should adjoin the main stock pond, and is often built either at its exit or around the outlet or main sluice gate of the whole system. It should be well provided with gates, in order to control the flow of water equally well in either direction.

CATCHING MARKETABLE BAÑGOS

During high tide, water from the outside is allowed to flow into the fishpond where the marketable bañgos are. As soon as the fish feel the current they begin to swim against it until they reach the catching pond. They become so eager to force their way against the incoming current that they bump their snouts against the grating of the gate, crowd one another half out of the water, and even leap high in the air.

As soon as all the bañgos or as many as are wanted have entered the catching pond the sluice gates between it and the other ponds are closed. The fish should then remain in the koloñgan at least twenty-four hours before being caught. By that time the intestinal tract will be empty, and they will keep very much longer than when caught at once while full of food.

When sufficient time has elapsed, a large seine is dragged across the koloñgan from end to end or one side to the other. During this operation there is great excitement. As the fish become crowded they dart to and fro with great speed or leap high in the air. Frequently they jump clear over the net. I have seen them leap at least two meters above the surface of the water, passing high above the net. Usually the seine is hauled to the bank and lifted section by section, the captured

fish being placed in a banca. The pond is swept several times by the seine until all or practically all the bañgos are caught. Some ponds have a runway at the lower end into which the fish are driven by the net, which finally closes the upper end of the runway, or the runway may be closed by a sluice gate at each end. The densely crowded fish are then easily lifted out by long-handled dip nets.

If the bañgos are placed in a banca they are transferred to large baskets when the boat is brought to the shore. The fish are then laid out and sorted into the standard sizes. All fish of other kinds, such as apahap, banak, bia, bid-bid, kitang, and the like, if any have been caught, are also placed in separate piles.

After the bañgos have been sorted ten or a dozen should be taken from each pile and weighed. The weight obtained is divided by the number weighed to get the average weight. This, multiplied by the total number in each pile, is taken as the weight of all the bañgos in each group. Every progressive fishpond owner who wishes to keep a careful account of his income and expenses, profits and losses, should weigh his fish. As a matter of fact most owners do not do it.

Sometimes when the incoming water is muddy or not clear the bañgos refuse to swim against it, and then of course cannot be lured into the catching pond. The fishpond owners also believe that bañgos which have escaped from the kolonñgan, or which have bumped their snouts against the wall or sluice gate when swimming against the current, have more or less influence over the rest and lead them away from the kolonñgan.

When the fish will not go into the catching pond they are caught by dragging a seine across the kaloañgan, or large pond. This is a very poor method. The fish are full of partially digested food, which decays rapidly, causes the fish to have a bad odor in a short time, and lowers their value and salabity.

The fish should be caught for market late in the evening or at night, so that they will be in good condition in the market the following morning. Around Manila Bay the large producers put their bañgos in a motor boat, or in a large banca towed by a launch, and rush them to Manila, reaching there about 4 o'clock in the morning. Producers along the coast of Bataan Province pack their fish in ice and ship them to Manila on small local steamboats. Fish from ponds at the more-interior points in Bulacan and Pampanga Provinces and near railway stations are packed in ice and shipped by rail to adjacent provinces

such as Tarlac, Pangasinan, Nueva Ecija, and Laguna. Some bañgos are also shipped by truck to neighboring towns. Generally bañgos packed in ice bring a lower price than fish not iced.

In some regions, especially in Panay, several ingenious methods are in use for the capture of marketable fish. In the vicinity of Barotac Nuevo the following method is used: Two small inclosures, each about 2 meters wide and 4 meters long are built adjoining one corner of the main pond, after the manner of the diagram in fig. 6. During high tide the gates A, B, C, and D and also baklad 2, 3, and 4 are opened, leaving only baklad 1 closed. Water accordingly flows freely into the

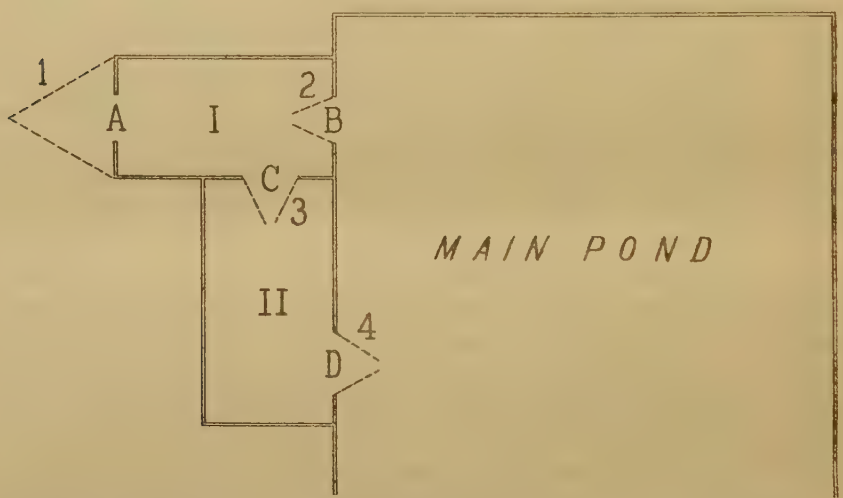


FIG. 6. Plan of a fishpond and small catching ponds used at Barotac Nuevo, Iloilo Province, Panay.

pond, and the bañgos swimming against the current enter catching pond I, through gates B, D, and C, after which all the gates are closed. At low tide gates C and D are opened, but baklad 4 is kept closed. The fish in compartment I will then swim against the current flowing through C and D and enter compartment II, after which gate C is closed. From compartment II the bañgos may be taken by a net in the manner already described.

This is a clever scheme as it leaves compartment I free to be utilized for any purpose needed. The baklad can likewise be used for catching shrimps and for fishes other than bañgos.

Compartments I and II are too small for a fishpond system of much size, but this is a matter of detail easily adjusted.

Another method, generally used in Java and widely current in the Visayas, is to construct a baklad in the main pond, around the inner side of the sluice gate; sometimes it may be placed in the canal or creek outside the gate. If the baklad is outside the pond, the gate is opened at high tide when it is desired to catch fish. The bañgos swimming against the current pass through the gate and enter the baklad. As soon as the tide turns and the current slackens, the gate is closed, leaving the fish in the center of the baklad. From this they are easily removed with a long-handled dip net. This is an excellent method for small ponds or for catching limited quantities of fish, but is not adapted for the handling of large numbers of bañgos.

When the baklad is within the pond, doors are opened in the baklad through which the fish can enter it at high tide. These doors are closed at low tide, thus confining the fish within the baklad.

All the above methods are subject to many variations, but the principle in each is embodied in those outlined above.

BAÑGOS PONDS IN JAVA

I have recently had the privilege of examining the methods of bañgos culture now in use around the city of Batavia, Java. The industry is much more extensively developed in the vicinity of Samarang, Surabaya, and on Madura Island, but my stay in those places was too brief to permit of an examination of the fishponds there.

The bañgos industry in Java is entirely in the hands of Chinese, and the ponds are located in the nipa and mangrove swamps along the coast. Three hundred years ago the territory now occupied by fishponds at Batavia, between Pasar Ikan and the open sea, on both sides of Kali Besar, was all open water. The land has been built up during that time for 1 to 3 kilometers beyond Pasar Ikan, by the encroachment of mangroves upon the sea.

In general, the bañgos ponds were well laid out and conveniently arranged, but in no case were the sluice gates or principal gates solidly constructed of permanent or durable material, such as stone or concrete. The ponds were not as well kept as the ponds about Malabon, and the general practice of fishpond management in Rizal, Bulacan, and Pampanga Provinces is much superior to anything I saw around Batavia.

The ponds themselves are well constructed but the small, cheaply built sluice gates, and gates within the system, give an

air of cheapness and shabbiness, compared to the large, strong, handsomely made concrete gateways seen in the better class of ponds about Manila Bay.

Many of the ponds have a small baklad on the inner side of the gate, so that when water is allowed to enter the bañgos swimming against the current can be caught in the baklad, dipped out, and sent to market.

Apparently no ponds are provided with special inclosures for catching marketable bañgos. The usual method of catching bañgos is as follows: At each end of a pond a row of fishermen is stationed, each man provided with a cast net. Stepping into the water and wading slowly forward in line, each man throws his net whenever he sees bañgos or the water moved by fish. All fish caught are placed in a bag trailed behind. The escaping fish rush back and forth between the advancing lines; now and then some rush past the men and escape behind. When the rows of men are near each other a gill net is stretched upright across the pond behind each file of fishermen. The fish rush wildly to and fro in their efforts to escape, frequently leaping high into the air and occasionally vaulting clear over a gill net; others rush headlong into one of the gill nets. It there are many fish the scene is often very exciting. The fishermen have their cast nets in operation all the time, and their shouts and splashing add to the wild frenzy of the terrified bañgos.

When the fishermen are not able to catch enough to make it worth while they go back to their respective stations at the ends of the pond, which is then gone over in the same manner a second time.

OTHER FISHES FOUND IN BAÑGOS PONDS

As already explained, it is very difficult to prevent the entrance of other kinds of fishes into bañgos ponds. Not only are certain kinds found mixed with the bañgos fry in the palayok, as previously set forth, but the young of many other kinds pass through the meshes of the bamboo screens when fresh salt water is admitted at high tide.

Often the sluice-gate tender is careless, and leaves the outer bamboo screen up so that the space next the river is entirely open. Careless workmen may let the outer screen down only when water is admitted at high tide. This should not be tolerated. Manifestly any fish lurking about could dart through when the boards of the solid gate are lifted to let in the fresh tidal water. Large fish of certain kinds, such as dalag, are

able to eat hatirin and even garoñgin and often produce eggs at once, which soon hatch into a horde of ever-hungry carnivorous fish that are terribly destructive in a nursery pond.

If the boards of the central partition do not fit tightly, or have small holes in them, the fry of many carnivorous fishes may enter if the outer bamboo screen is left up. The outer bamboo screen at least should be kept lowered at all times.

If the pond is near a bay or other large body of salt water, bubuntis, bia, or gobies of many kinds, several kinds of eels, banak, ambassids, or langaray, kitang, buan-buan, apahap, talakitok, sap-sap, halfbeaks, and ayuñgin are found in greater or lesser abundance. If the pond is at some interior point where it may be flooded by fresh or only slightly brackish water it will be very difficult to keep out dalag and liwalo, two very dangerous enemies.

The fish of greatest abundance in bañgos ponds, after bañgos itself, is a small fish, *Mollienisia latipinna* Le Sueur, belonging to the family Poeciliidæ, which was inadvertently introduced from Hawaii. It is a viviparous fish, with strongly differentiated sexes; the female produces from fifty to seventy-five living young at a time. The Tagalog name of this fish is "bubuntis," meaning "pregnant," because of the deep protuberant belly of the female.

Bubuntis feed upon lab-lab, and therefore compete with bañgos fry, and when abundant greatly reduce the amount of food available for the bañgos fry. As the adult male bubuntis is never more than 40 millimeters in length, and a female never more than 48 millimeters long, they are too small to be valued as food in the fishpond districts. In the Philippines any fish visible to the naked eye is usually considered good food if it can be obtained in quantity. Bubuntis is an exception to this, because its flesh is bitter.

Bubuntis occur in enormous numbers in bañgos ponds, especially those of high salinity. They thrive in the ponds where salt is made, being able to enjoy life where no other Philippine fish can exist. We have obtained them in ponds where the salinity was 8.3 per cent, or nearly three times the normal salinity of Manila Bay. I have seen schools of bubuntis of at least twenty-five thousand individuals in the catching pond of a bañgos-pond system. With the large dip net used for catching young bañgos five to ten thousand bubuntis were taken up at a single scoop.

The only way to get rid of bubuntis is to drain, clean, and dry the pond. They are abundant in the salt-water tidal creeks

along the border of Manila Bay. It will probably be impossible to prevent them from entering with tidal water.

Bid-bid and buan-buan are swift, rapidly growing, voracious, carnivorous fishes distantly related to bañgos. As already stated, they are often caught with bañgos fry and are mixed with them in the jar. Buan-buan also enter fresh-water rivers and lakes and frequently enter bañgos ponds when water is admitted through the gratings in the sluice gates. Every effort should be made to keep them out as they devour many fry and hatirin.

Gobies, or bia, of many kinds occur in fish ponds and all of them are injurious to young bañgos. After the fry have reached the garoñgin stage they are in no further danger from gobies.

The commonest, largest, and most-dangerous goby in fishponds is *Glossogobius giurus,* or biang puti. It is very abundant in both salt and fresh water, and usually, if not always, spawns in the sea. The young ascend rivers in schools, and some of them are almost sure to gain entrance through the sluice gates of fishponds. If they get into a pond of fry or hatirin they devour them wholesale. Biang puti are readily salable in the market, and if taken from a pond of bañgos too large to be injured may be considered as clear gain, but if they have been feeding upon bañgos fry their presence is a distinct loss. Another goby dangerous to fry is the mud skipper, or talimosak, already mentioned. Names the gobies more or less abundant in fishponds are given on pages 494 and 495.

Many kinds of small eels frequent fishponds and are very destructive to fry and hatirin. Most of them are snake eels, belonging to the genera *Pisodonophis* and *Ophichthus.* One of the rice-paddy eels, *Synbranchus bengalensis,* is also abundant in bañgos ponds. Fortunately an eel related to the conger eels, *Muraenesox cinereus,* is not so common, as it is very voracious, grows to a large size, and is able to eat marketable bañgos.

When the fishponds are drained many hundred eels and equally large numbers of the smaller kinds of gobies are often taken and sold in the Manila market.

Several kinds of banak, or mullets, enter fishponds. Mullets are strictly vegetarian, living largely upon the organisms contained in the surface layer of mud at the bottom, as well as upon algæ. They do no harm to bañgos and are better food fishes.

One of the worst enemies of bañgos is the apahap, a member of the sea bass family. Apahap grow to a large size, and in a pond that has not been drained for a couple of years they may be a meter long, able to devour bañgos of marketable size. Apahap are of very fine quality as food and always bring a high price in the market, but they are an expensive luxury for the proprietor of a bañgos pond since they gobble large numbers of bañgos at all stages of growth.

Kitang are well-flavored fish abundant in rivers and estuaries and are sometimes found in fishponds. As they are vegetarian or scavengers they cannot harm the bañgos and their presence is not objectionable.

Halfbeaks are also harmless unless they obtain entrance to the nursery pond.

Ambassids, or langaray, are small translucent fish that occur in enormous numbers in rivers near the sea and tidal creeks. They are very destructive to kawag-kawag if they obtain entrance to the nursery pond, and are also harmful to hatirin. They are harmless to bañgos fry 40 millimeters or more in length.

Now and then a few talakitok, or pampanos, enter a fishpond. They are very fine food but are destructive to bañgos in the kawag-kawag, hatirin, and garoñgin stages.

Ayuñgin occur in both fresh and salt water. A few in a nursery pond would devour a great many fry. However, they are not abundant in fishponds, as a rule, unless the salinity is reduced, as in the rainy season.

If the water in a fishpond has its salinity greatly reduced, or is exposed to freshets or floods of fresh water in the rainy season, dalag will be almost sure to enter. Dalag are not only very active but during the rainy season leave streams and wander about on land wherever there is a trickle of water. They easily leap upon or over low dikes, when their actual height has been reduced by floods or high water. Only high well-kept dikes, free from holes or leakage, will keep out dalag. Fortunately they cannot live long in sea water of normal salinity or above. Therefore, the best preventative of dalag is to keep the water in the ponds up to normal salinity. Then those which enter will not be able to do much harm and will soon become blind and die shortly after.

Where it can survive, the dalag is one of the most dangerous enemies of bañgos. A few dalag in a nursery pond will soon

eat every kawag-kawag in it. No effort should be spared to keep dalag out of bañgos ponds.

Liwalo or puyo, the climbing perch, is also a serious menace in bañgos ponds with water of reduced salinity, especially in the rainy season, when few ponds are without them.

Climbing perch can live in saltier water than dalag can, but are not so dangerous to the bañgos grower. They do not reproduce so rapidly or in such numbers as dalag do, and are not so voracious. However, their presence in a nursery pond is a serious matter and they should be exterminated as soon as possible whenever found in a bañgos pond.

The following list includes all the fishes besides bañgos thus far collected from bañgos ponds in the Philippines:

Ambassis kopsi Bleeker; lañgaray.
Ambassis urotaenia Bleeker; lañgaray.
Amia quadrifasciata (Cuvier and Valenciennes).
Anabas testudineus (Bloch); climbing perch; liwalo; puyo.
Anchovia baelama (Forskål); anchovy; dilis; bolinao.
Anchovia mystax (Bloch and Schneider); anchovy; dilis; bolinao.
Arius manillensis (Cuvier and Valenciennes); catfish; kanduli.
Arius thalassinus (Rüppell); catfish; kanduli.
Butis butis (Buchanan Hamilton); goby; bia.
Caranx calla (Cuvier and Valenciennes); pampano; talakitok.
Caranx ignobilis (Forskål); pampano; talakitok.
Chonophorus lachrymosus (Peters); goby; bia.
Cirrhimuraena tapeinopterus Bleeker; eel; palos.
Clupanodon nasus (Bloch); kabasi.
Clupeoides lile (Cuvier and Valenciennes); sardine.
Congrogadus subducens (Richardson).
Creisson validus Jordan and Seale; goby; bia.
Elops hawaiiensis Regan; Jackmariddle; bid-bid.
Evenchelys macrurus (Bleeker); eel; ogdok.
Gerres punctatus (Cuvier and Valenciennes).
Glossogobius giurus (Buchanan Hamilton); goby; bia; biang puti.
Gnatholepis puntangoides (Bleeker); goby; bia.
Harengula fimbriata (Cuvier and Valenciennes); sardine.
Hemiramphus gaimardi Cuvier and Valenciennes; halfbeak; buguing; bayamban.
Hemiramphus marginatus (Forskål); halfbeak; buguing; bayamban.
Lates calcarifer (Bloch); apahap.
Leiognathus caballus (Cuvier and Valenciennes); sapsap.
Leiognathus fasciatus (Lacépède); sapsap.
Leiognathus splendens (Cuvier); sapsap.
Liza coeruleomaculata (Lacépède); mullet; banak.
Liza melinoptera (Cuvier and Valenciennes); mullet; banak.
Liza troscheli (Bleeker); mullet; banak.
Liza waigiensis (Quoy and Gaimard); mullet; banak.
Lutianus chirtah (Cuvier and Valenciennes); snapper.
Megalops cyprinoides (Broussonet); little tarpon; buan-buan.

Mionurus bombonensis Herre.
Mollienisia latipinna Le Sueur; killifish; bubuntis.
Monodactylus argenteus (Linnæus).
Mugil dussumieri Cuvier and Valenciennes; mullet; banak.
Muraenesox cintereus (Forskål); eel.
Muraenichthys gymnopterus Bleeker; eel; palos.
Muraenichthys malabonensis Herre; eel; palos.
Ophicephalus striatus Bloch; dalag.
Ophichthus apicalis (Bennett); eel; palos.
Ophicthus celebicus (Bleeker); eel; palos.
Ophichthus manilensis Herre; eel; palos.
Ophiocara aporos (Bleeker); goby; bia.
Ophiocara porocephala (Cuvier and Valenciennes); goby; bia.
Oxyurichthys microlepis Bleeker; goby; bia.
Oxyurichthys viridus Herre; goby; bia.
Periophthalmodon schlosseri (Pallas); mudskipper; talimosak.
Periophthalmus barbarus Linnæus; mudskipper; talimosak.
Pisodonophis boro (Buchanan Hamilton); eel; palos; pindanga.
Pisodonophis cancrivorus (Richardson); eel; pindanga.
Plotosus canius (Buchanan Hamilton); catfish; alimosang.
Pomadasys hasta (Bloch).
Priopis buruensis (Bleeker); lañgaray.
Pseudorhombus arsius (Buchanan Hamilton); flounder; dapa; palad.
Rhinogobius caninus (Cuvier and Valenciennes); goby; bia.
Rhinogobius viridi-punctatus (Cuvier and Valenciennes); goby; bia.
Scatophagus argus (Gmelin); kitang.
Sillago sihama (Forskål).
Sphyraena jello Cuvier and Valenciennes; barracuda; babayo.
Synbranchus bengalensis (McClelland); eel; palos.
Taenioides gracilis (Cuvier and Valenciennes); snake goby; eel goby.
Tetraodon immaculatus Bloch and Schneider; puffer; botete.
Tetraodon reticularia (Bloch and Schneider); puffer; botete.
Teuthis hexagonata (Bleeker); samaral.
Therapon argenteus (Cuvier and Valenciennes) ayuñgin.
Therapon jarbus (Forskål).
Therapon quadrilineatus (Bloch).
Tylosurus strongylurus (Van Hasselt); gar.
Umbrina russelli Cuvier and Valenciennes.
Upeneoides sulphureus (Cuvier and Valenciennes); goatfish; timbuñgan.
Vaimosa piapensis Herre; goby; bia.
Zenarchopterus dispar (Cuvier and Valenciennes); halfbeak; siliuw.

CRUSTACEA FOUND IN BAÑGOS PONDS

Several kinds of shrimps usually occur in large quantities in bañgos ponds, especially the kind known as sugpó. Small traps, modelled after large fish corals but made especially for shrimps, are placed in the fishpond and the shrimps removed from them by dip nets every morning. As previously stated, shrimps are not harmful if they are not allowed to enter the nursery pond.

Several species of crabs are found in bañgos ponds, and if of the best marketable kind may bring considerable revenue to the fishpond owner. Crabs (alimañgo) of several kinds sell for 20 to 30 centavos each; large females in good condition bring even more. Alimasag, crabs of the genus *Neptunus*, bring a lower price. In regions near the sea the crab called dakomo is very abundant in fishponds and does much damage by burrowing in the banks.

In spite of the fact that crabs may contribute to the income, their presence in a bañgos pond is a source of more expense than revenue. They burrow large holes in the dikes, which must be closed or otherwise the leakage will soon be beyond control. Their holes cause much loss of water, or the entrance of fresh water (not salt), and they allow water snakes, eels, dalag, and other enemies to get into the fishpond.

Another burrowing crustacean very harmful to fishpond dikes is the sea mantis. At least three species of this peculiar group are found in bañgos ponds, requiring frequent patrol of the dikes to keep them in check.

The following Crustacea have been identified from fishponds about Manila Bay and in the Visayan Islands:

Alphaeus sp.; pistol crab.
Goniosoma merguiense de Man; crab.
? Goniosoma orientale (Dana); crab.
Gonodactylus scyllarus Linnæus; sea mantis; ulapihan dagat.
Grapsidæ, sp.; crab, kais-kaias.
Lysiosquilla maculata Fabricius; sea mantis; ulapihan dagat.
Metapograpsus maculatus Edwards; crab; grumente.
Neptunus pelagicus (Linnæus); crab; alimañgo.
Palaemon carcinus Fabricius; shrimp; ulang. This is very abundant in water of low salinity. The adults are dangerous to small fish.
Palaemon sundaicus Heller; shrimp; ulang.
Parapeneopsis sp.; shrimp; ulang.
Peneus monodon Fabricius; shrimp; ulang; sugpó.
Peneus semisulcatus De Haan; shrimp; ulang; sugpó.
Scylla serrata (Forskål); crab; kalungkot; alimañgo.
? Sesarma palawanense Rathbun; crab.
Sesarma taeniolata White; crab; dakomo. Abundant and very destructive to fishpond dikes.
Squilla nepa Latreille; sea mantis; ulapihan dagat.
Thalamita crenata (Latreille); crab; alimañgo.
Thalamita danae Stimpson; crab; alimañgo.
Thalassina anomala (Herbst); sea scorpion.
Uca acutus (Stimpson) fiddler crab; bangi-bangi.
Uca annulipes (M. Edwards); fiddler crab; bangi-bangi.
Uca dussumieri (M. Edwards); fiddler crab; bangi-bangi.

TECHNICAL DESCRIPTION OF THE BAÑGOS

The ancient family of isospondylous fishes Chanidæ belongs to the suborder Clupeoidei, or herringlike fishes. It contains but one living genus, with only one species of very wide distribution in tropical Indo-Pacific waters. Remains of some extinct fishes have been found in Cretaceous, Eocene, and Miocene beds that are classified in this family and assigned to the genera *Chanos* and *Prochanos*.

Body elongate, moderately compressed, and pointed at both ends, with a broad rounded abdomen; head naked, with a large, transparent, imperforate, adipose eyelid covering eye and side of head; trunk covered with firm, closely adherent, relatively small or medium-sized silvery scales; dorsal and anal each with a broad basal sheath; pectoral with a long pointed axillary scale above and below; ventral with a pointed axillary scale above; small scales extend upon the caudal; snout depressed; mouth small, terminal, transverse, and toothless; lower jaw slightly included, with a symphysial tubercle which fits into a notch in the upper jaw between the premaxillaries; the maxillaries short and broad with no supplemental bone; premaxillary joined to the upper anterior edge of maxillary; ventrals well developed, opposite the posterior half of dorsal; anal very much smaller than dorsal and placed very far back; caudal large, deeply forked; lateral line straight, each scale with a single tube; gill membranes entirely united below and free from the isthmus; four long branchiostegals; pseudobranchiæ well developed; gill rakers exceedingly fine, numerous, and close set, in two diverging rows; an accessory branchial organ in a cavity behind the gill cavity proper; air bladder divided by a constriction into an anterior and posterior portion; mucous membrane of the œsophagus raised into a spiral fold; pyloric appendages numerouus; intestine very long and with many convolutions, the peritoneum black.

The fishes of this family are large and have the general appearance of a very large cyprinid; they are found throughout the warmer parts of the Indo-Pacific Ocean. The synonymy of the one living genus of this family follows.

Genus CHANOS Lacépède

Chanos LACÉPÈDE, Hist. Nat. Poiss. 5 (1803) 395.
Lutodeira VAN HASSELT, Ferrusac, Bull. general Sciences 2 (1824) 92.
Ptycholepis RICHARDSON, Ann. and Mag. Nat. Hist. I 11 (1843) 489.

The characters of the single genus are included in those of the family.

In the Zoölogy of the Erebus and Terror, Fishes, Sir John Richardson states on page 58 that he and not Mr. Gray is the author of the name *Ptycholepis*. The usual reference of *Ptycholepis* to Gray, 1842, seems to be a mistake. The second volume of Dieffenbach's Travels in New Zealand, in which Gray's description appeared, was published in 1843. Richardson says:

> This subgenus . . . already been named by me in a Report on the Ichthyology of New Zealand, read at the Meeting of the British Association in June 1842, and in the Appendix to Dr. Dieffenbach's account of New Zealand.

Following is a list of the technical names that have been applied to the only known species of the genus and a technical description of the species.

CHANOS CHANOS (Forskål).

Mugil chanos FORSKÅL, Descript. Animal (1775) 74; BLOCH and SCHNEIDER, Syst. Ichth. (1801) 116.

Mugile chani BONNATERRE, Encyclop. meth., Ichthy. (1788) 180.

Mugil salmoneus (Forster) BLOCH and SCHNEIDER, Syst. Ichth. (1801) 121; FORSTER, Descript. Animal, ed. Lichtenstein (1844) 299.

Chanos arabicus LACÉPÈDE, Hist. Nat. Poiss. 5 (1803) 396; CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 135.

Palah bontah RUSSELL, Fishes of Coromandel 2 (1803) pl. 207.

Tooleloo RUSSELL, Fishes of Coromandel 2 (1803) pl. 208.

Lutodeira indica VAN HASSELT, Algem. Konst. en Letterb. (1823) 333; Bull. Sci. Nat. (Ferussac) 2 (1824) 92.

Lutodeira chanos RÜPPELL, Atlas, Fische rothen Meers (1828) 18, pl. 5, fig. 1, *a* and *b*.

Cyprinus (*Leuciscus*) *palah* CUVIER, Regne Animal, ed. 2, 2 (1829) 222, after Russell.

Cyprinus tolo CUVIER, Regne Animal, ed. 2, 2 (1829) 222, after Russell.

Leuciscus zeylonicus BENNETT, Proc. Zoöl. Soc. London (1882) 184.

Leuciscus (*Ptycholepis*) *salmoneus* RICHARDSON, Ann. and Mag. Nat. Hist. I 11 (1843) 489; GRAY, in Dieffenbach, Travels in New Zealand 2 (1843) 218.

Chanos mento CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 141.

Chanos chloropterus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 141; KNER, Reise Novara, Fische (1865) 341.

Chanos nuchalis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 142.

Chanos orientalis CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 143; EYDOUX and SOULEYET, Zoöl. Voy. Bonite, Atlas, Poiss., pl. 7, fig. 1; KNER, Reise Novara, Fische (1865) 341.

Chanos cyprinella CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 144.

Chanos lubina CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 145, plate 533; GÜNTHER, Cat. Fishes 7 (1868) 474; BLEEKER, Atlas Ichth. 6 (1866–1872) 82.

Chanos salmoneus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 19 (1846) 146; GÜNTHER, Cat. Fishes 7 (1868) 473; BLEEKER, Atlas Ichth. 6 (1866–1872) 81, pl. 272, fig. 4; GÜNTHER, Report Challenger Exp., Zoölogy 1 (1880) pt. 6, Shore Fishes, 61; DAY, Fishes India, (1878) 651, pl. 166, fig. 2; BOULENGER, Trans. Linn. Soc. London II 12 (1909) 291.

Lutodeira salmonea RICHARDSON, Zoölogy Erebus and Terror, Fishes (1844–1848) 58, pl. 36, figs. 1 and 2.

Butirinus argenteus and *maderaspatensis* JERDON, Madras Journ. Lit. and Sci. 15 (1849) 343, 344.

Chanos pala and *tolo* CANTOR, Cat. Malayan Fishes (1849) 278 and 282.

Chanos indicus BLEEKER, Enum. Pisc. Arch. Ind., Act. Soc. Sci. Indo-Neerl. 6 (1859) 160.

Lutodeira chanos GÜNTHER, Fishes of Zanzibar (1866) 120.

Lutodeira chloropterus PLAYFAIR, Proc. Zoöl. Soc. London (1867) 868.

Chanos chanos KLUNZINGER, Verh. Zoöl.-Bot. Gesell. Wien 21 (1871) 605; JORDAN and EVERMANN, Bull. U. S. Nat. Mus. 47 1 (1896) 414; STEINDACHNER, Denks. Ak. Wiss. Wien 70 (1900) 514; JENKINS, Bull. U. S. Fish Comm. 22 (1902) (1903) 432; JORDAN and EVERMANN, Proc. U. S. Nat. Mus. 25 (1903) 327; JORDAN and SNYDER, Proc. U. S. Nat. Mus. 28 (1904) 123; JORDAN and EVERMANN, Bull. U. S. Fish Comm. 23, pt. 1 (1903) (1905) 56, fig. 10; JORDAN and SEALE, Bull. Bur. Fisheries 25 (1905) (1906) 186; JORDAN and HERRE, Proc. U. S. Nat. Mus. 31 (1906) 622; JORDAN and SEALE, Bull. Bur. Fisheries 26 (1907) 4; EVERMANN and SEALE, Proc. U. S. Nat. Mus. 31 (1907) 505; JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 (1908) 236; GÜNTHER, Fische der Südsee 3 (1910) 387; WEBER, Siboga Esp., Fische (1913) 3; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 2 (1913) 15, fig. 8; JORDAN and TANAKA, Annals Carnegie Mus. 17 (1927) 260.

Vernaular names: English, milkfish; Bicol, *bañgos;* Ilocano, *awa, banglot;* Pampango, *bañgos,* Pangasinan, *awa, betel;* Tagalog, *bañgos, bañglis, bañgris, laón, lumulokso, hatirin, garoñgin;* Samal and Tao Sug, *bangilis;* Visayan, *awa, banglus, bañgos, bañgros;* Malay, *bandang, jangas;* Javanese and Sundanese, *bandeng;* Hawaiian, *awa, awa-awa, awa-kalamoku, puawa;* Society Islands, *ava, awa;* Canarese, *hu-meen;* Tamil, *tulu caudal;* Telugu, *palah bontah;* Tulu, *pu-meen;* Arabic, *anged, anget;* Spanish, *sabalo.*

Names of bañgos fry: Ilocano, *bugi;* Pampango, *ka-kawag;* Tagalog, *kawag-kawag;* Visayan, *awa-awa.*

Dorsal II, 12 or 14; anal II, 8 or 9; pectoral I, 15 or 16; ventral 1, 10 or 11; seales in lateral line 75 to 85 + 5 to 11 on

caudal base; 12 or 13 scales above lateral line to origin of dorsal, 10 or 11 below to origin of anal; vertebræ 26 + 18 = 44.

Body elongate, compressed, thicker with age; head and anterior part of trunk much broader proportionately and head relatively shorter in large old specimens; depth 3.5 to 3.75 in length; head 3.5 to 3.8 in length, equal to or less than depth; snout broad, usually about three-fourths in eye, 4.1 to 4.55 in head; eye large, 2.75 to 3.5 in head, usually 3.25 to 3.5; in the young the broad flat interorbital equals the eye; in mature or large specimens it becomes rounded and is a fourth or nearly half again as broad as the length of the eye; maxillary broad, slipping under the adipose preorbital, without a supplemental bone; dorsal nearer base of caudal than tip of snout (not nearer snout as stated by Jordan and Evermann; their figure is correct); dorsal with a large scaly basal sheath which is elongated posteriorly, the anterior falcate ray 1.32 to 1.42 in head, the last ray produced in a short filament; the anal resembles the dorsal but is very much smaller, its height 3.36 to 5.9 times in the head; the least depth of the powerful caudal peduncle is 2.7 to 2.85 times in the head in young, 3.3 times in adult or nearly mature specimens; the caudal is very large and deeply forked, the upper lobe slightly larger, 2.44 to 2.88 times in the length, not forked to the base as stated by many authors; the pointed pectoral is 1.85 to about 1.6 times in the head; the pointed axillary scale above 1.5 to 2 times in the pectoral, the axillary scale below much shorter; the ventral is 1.85 to 2.15 times in the head, its pointed axillary scale about 1.8 times in its own length; below each ventral is a very wide pointed scale. The caudal is not included in the length.

The color in life is brilliant silvery over all, brilliant glossy blue or bluish olive above, the top of the head yellowish olive, the sides whitish, the underside of the head white; side of the head with golden glints and opalescent luster; golden luster also along sides on some specimens; dorsal more or less yellowish, and yellowish along the mid-line of the back behind the dorsal; the fins colorless or the pectorals, ventrals, and anal more or less yellow; the caudal gray or colorless with a blackish posterior margin, or the lower lobe yellowish. Some specimens have the inside of the pectorals and ventrals dusky to black.

The color in alcohol is bluish above, the lower half merging gradually into white underneath, a brilliant silver luster over all; the fins all whitish, or the dorsal and caudal dusky, the eye

more or less deep reddish yellow; after many years specimens may turn reddish brown above, pale brownish below; large specimens have the dorsal, caudal, and tip of anal dusky, the inside of the pectorals and ventrals blackish.

Adult bañgos are from about three-fourths of a meter to a meter and a half in length, exclusive of the caudal fin. Specimens of this size differ much from the young in the shape of the top of the head and the anterior portion of the body. Specimens a meter or more in length are much bulkier in proportion, and at the shoulder girdle may be as large round as a man's thigh. The top of the head is flat in the young and becomes convex in the adult.

INDUSTRIES ALLIED TO BAÑGOS GROWING

There are three industries that are often correlated with the rearing of bañgos and which can be developed with it to a much greater extent than is done at present.

NIPA THATCH

Nipa occurs naturally along esteros in many fishpond districts, and does well planted as a screen to protect the dikes from floods and the effects of strong currents. In many localities much more could be grown than is there at present. By increasing plantings to the capacity of the ground, additional income from the sale of nipa thatch could be derived at very little more trouble and expense. Nipa thatch sells at present for 10 to 15 pesos a thousand.

FUEL FROM MANGROVE

When fishponds are located in mangrove swamps the dikes should be protected from tides, floods, and currents which threaten to undercut or erode the bank, by planting one or more rows of mangrove. A limited number of mangrove trees can also be planted along the main dikes of the pond system. Bacaoan, or mangrove, is a hard wood which is in steady demand for fuel, and from which excellent charcoal is made. At present charcoal from bacaoan sells for 2 to 2.50 pesos a sack. In a good-sized fishpond system a small but steady income could be derived from the sale of either fuel or charcoal, if the dikes were protected along the outside by a belt of properly handled mangrove trees. The Bureau of Forestry would gladly advise fishpond owners as to the best methods of handling mangrove or nipa.

SALT MAKING

The most important allied industry and one closely related to bañgos culture is making salt by solar evaporation. Many of the ponds about Bulacan, Malolos, Obando, Navotas, Malabon, and Parañaque are used to rear bañgos during the rainy season and for salt making from early in February until the middle of May.

First a part of the ground in a fishpond is divided into a series of small plots (Plate 16 and text fig. 2). The first plot is 30 meters square, followed by a narrow one of 4 by 30 meters; then comes a row of four plots, each 30 meters square, and another one 4 by 30 meters. The last plot is also 30 meters square and is divided into small blocks each 2 by 4 meters. Each block, called banig, or mat, is made as follows: The earth is first excavated to a depth of about 125 millimeters, then filled in with 100 millimeters of gravel, over which is placed a layer of clay about 25 millimeters thick. On this is placed a layer of pieces of broken tinajas, or earthenware jars, fitted together to form a smooth hard floor. Between the banig, or blocks, are the channels for conducting salt water, and along the sides of the whole compartment are drainage ditches to carry off the surplus water.

The water is let into the first compartment to a depth of about 30 centimeters. Later in the same day it is admitted to the second compartment. After remaining in these two compartments for twenty-four hours the water is let into the four succeeding compartments, remaining in each one for twenty-four hours. Compartments three and four are subdivided lengthwise into four equal parts, compartments five and six into three each. The water is then let into the narrow seventh compartment and from it runs into the last one. By that time it is only about 10 centimeters deep. Water let into the last division has evaporated to salt by late afternoon or earlier. It is scraped into piles to facilitate handling and promote drying beneath, then gathered into a large basket called tiklis. In a good season one banig, or unit, yields one tiklis of salt, worth 50 centavos. At this rate a salt pond a little more than half a hectare in area will yield from 300 to 400 pesos' worth of salt during the season.

FISH PONDS UNDER THE BUREAU OF FORESTRY

Permits to operate fishponds have been issued by the Bureau of Forestry under the provisions of Section 1838 of the Adminis-

trative Code in the following provinces: Bohol, Bulacan, Camarines Sur, Capiz, Cavite, Cebu, Davao, Ilocos Norte, Iloilo, Marinduque, Masbate, Mindoro, Misamis, Occidental Negros, Oriental Negros, Pampanga, Pangasinan, Rizal, Sorsogon, Tayabas, Zambales and Zamboanga. Most of the 390 permits granted are for small areas in mangrove swamps, and most of the permittees are still busy gathering firewood, nipa, timber, or forest products in the area covered by their permits. The only provinces in which the permits granted by the Bureau of Forestry are of any importance in the production of bañgos are Cebu, Iloilo, Mindoro, and Pangasinan. The table appended, which had been compiled by the Bureau of Forestry from reports submitted by fishpond lessees and permittees, shows that the returns per hectare of the fishponds on the Bureau of Forestry lands are very low and that the value of the fry is disproportionately high to the returns obtained. For example, compare the value of the fry released in Pangasinan with the value of the fish marketed.

The gross returns for bañgos per hectare are highest in Mindoro, over 70.84 pesos per hectare. The next highest are 40.90 pesos in Pampanga, 23.46 pesos in Pangasinan, 18.50 pesos per hectare in Iloilo, and 16.03 pesos in Cebu. The returns in other provinces are so low that it is very evident the fish were raised at a lost. If any thing is charged for interest on the cost of the dikes, for time, and for labor, the owner would have been better off without a fishpond. Money received for firewood probably enabled some of the permittees to operate with a gain.

Deducting nothing for labor, management, or the cost of dikes, and omitting returns for firewood, the table shows that the average returns for bañgos fishponds operated under Bureau of Forestry leases was 11.64 pesos per hectare for 1926. The average cost of the dikes on the same fishponds was a little over 51 pesos per hectare. At this rate, with no charges for labor, management, repairs, or improvements, it would take five years to pay for the cost of the dikes. Taking the provinces singly the table shows that the returns from bañgos will pay for the dikes, allowing nothing for any expenses or interest, in from one and a half years (Masbate), and three and a half years (Iloilo), to many years in some of the provinces, even if Tayabas is excluded. This is a very unfavorable showing as compared with privately owned fishpond lands, but it would be very unfair to compare the two as yet, since most of the

Bureau of Forestry fishpond operation, compiled from reports submitted by lessees and permittees during the year 1926.

Province.	Dike.		Fish.			Firewood invoiced.	Trees planted.	Reports submitted.	Actually granted.	
	Length.	Cost.	Fry released.	Value of—					Permits issued.	Area.
				Fry.	Fish harvested.					
	Meters.	*Pesos.*		*Pesos.*	*Pesos.*	*cu. m.*				*Hectares.*
Bohol								1	1	3.80
Bulacan	934		1,000	14.00	80.00		10,000	1	4	34.27
Camarines Sur									1	4.00
Capiz	888	760.00	200	12.00	100.00		400	4	8	49.97
Cavite	254	1,524.00	400	12.00	60.00			1	1	.27
Cebu	25,085	25,697.46	151,850	1,068.61	5,277.65	95.00	3,630	98	144	262.46
Davao	600	2,800.00			50.00			1	4	59.61
Ilocos Norte									2	11.57
Iloilo	48,409	73,072.42	931,150	4,683.00	28,369.67	707.00	1,053	35	56	1,279.89
Marinduque									2	13.10
Masbate	177	565.00	13,000	265.00	735.00		500	5	5	53.90
Mindoro	686	2,622.00	520,800	120.00	4,100.00	358.00	20,700	2	4	56.18
Misamis									1	16.00
Occidental Negros	4,165	3,645.00	25,000	25.00	335.00	60.00	72,000	5	13	104.90
Oriental Negros	2,706	3,848.00	10,000	180.00	350.00	64.00	50	5	7	144.08
Pampanga	1,424	2,300.00	8,000	150.00	600.00		100	1	1	11.00
Pangasinan	48,083	25,221.83	385,200	1,497.30	3,364.00	5,008.04	3,426	79	111	795.60
Rizal									1	.46
Sorsogon									1	4.50
Tayabas	1,562	12,000.00	40,000	100.00	80.00	223.00		2	6	79.35
Zambales	2,504	1,818.00	11,200	37.00	78.00		650	9	16	53.78
Zamboanga									1	3.00
Total	137,477	155,873.71	2,097,800	8,163.91	43,579.32	6,515.04	112,509	249	390	3,041.69

fishponds on Bureau of Forestry lands are very new, as yet undeveloped, and have not had time to be placed on a paying basis. The life of a fishpond lease from the Bureau of Forestry is but ten years, but this may be extended to another ten years, when the property automatically reverts to the Government. During this second ten years the lessee may expect to reap a reasonable profit on his investment, and should have his lease further extended where he has complied with all the Bureau of Forestry regulations.

In the few provinces where constructed fishponds were already inspected by the Bureau of Forestry, it was found that all the mangrove trees, except narrow strips reserved for protection purposes along seashores or river banks, had been cleared as it is considered by many fishpond operators that the existence of mangrove trees within the pond is not conducive to the growth and development of milkfish. The cutting and utilization of mangrove trees within the area under permits before converting the same into fishponds are permitted under certain conditions.

It is therefore clear that from the first to the third years' operation of the permittees, they spend most of their time in removing and utilizing the forest growths from the areas to be constructed into fishponds, and the income derived therefrom is invested in the construction of fishpond dikes.

It is apparent that the mere possession of a piece of mangrove or other swamp, and the establishment of some sort of a fishpond on it, is not necessarily a sure way to wealth; it may be merely the forerunner to bankruptcy.

However, the bañgos-fishpond business is a certain and lucrative one if the owner has sufficient capital for the proper construction of his ponds and will put into it the same energy, prudence, and thought that he would put into the successful management of any other business.

ILLUSTRATIONS

PLATE 1

Bañgos, or milkfish, *Chanos chanos* Forskål.

PLATE 2

FIG. 1. A bañgos fry, or kawag-kawag; × 8. Actual length, 10 millimeters.
2. Roe of a bañgos containing over 3,000,000 eggs.

PLATE 3

FIG. 1. Clearing nipa from a fishpond site, Pilar, Bataan Province, Luzon.
2. Building a dike for a fishpond, on the Ayala estate, Palipit, Pampanga Province, Luzon.
3. Building a dike, fishpond of Simeon Blas, Totopiac Barrio, Bataan Province, Luzon.

PLATE 4

FIG. 1. A small pond dried to make ready for growing algæ (lab-lab). Three long basket traps (galao) can be seen on a bank.
2. Dike, main sluice gate, and watchman's hut, near Malabon, Rizal Province, Luzon.
3. Repairing a fishpond dike, Malabon.

PLATE 5

FIG. 1. Part of a nursery pond and a man with a galao.
2. Nursery pond, showing a small sluice gate with the bamboo screen partially raised, Obando, Bulacan Province, Luzon.
3. Nursery pond, with mangrove forest in the background, near Estancia, Iloilo Province, Panay.

PLATE 6

FIG. 1. A fishpond guardian and family.
2. A banca loaded with jars (palayok) full of bañgos fry (kawag-kawag), towed by motor boat from Manila to the Carlos Palanca estate, near Hagonoy, Bulacan Province, Luzon. April 29, 1927.
3. Men discarding dead fry (kawag-kawag) and making the number of living fish uniform in the various jars (palayok), on the Carlos Palanca estate, near Hagonoy, Bulacan. April 27, 1927.

PLATE 7

FIG. 1. Men catching young bañgos (garoñgin). The net (bitinan) is not lifted from the water. The fish are released in the large pond as they are counted. Ayala estate, Macabebe, Pampanga Province, Luzon. May 6, 1927.
2. Part of a 24-hectare fishpond being dried preparatory to growing algæ (lumut), on the Carlos Palanca estate, near Hagonoy, Bulacan Province, Luzon. April 27, 1927.
3. Part of a 24-hectare fishpond with a luxuriant growth of lumut, on the Carlos Palanca estate. April 21, 1927.

PLATE 8

FIG. 1. A fishpond with a perfect growth of lumut; a watchman's hut on the dike and nipa palms in the middle distance, on the Carlos Palanca estate, Hagonoy. April 22, 1927.
2. A fishpond showing dikes planted with mangrove, at Batang Barrio, Sexmoan, Pampanga Province, Luzon.
3. Fishponds with coco palms growing on a dike, at Paombong, Bulacan Province, Luzon.

PLATE 9

FIG. 1. Men counting bañgos fry (kawag-kawag), on the Carlos Palanca estate, Hagonoy, Bulacan Province, Luzon. April 27, 1927.
2. A nursery pond for bañgos, near Abucay, Bataan Province, Luzon. The fry are placed in the small inclosure shown in the foreground. May 3, 1927.
3. Men catching young bañgos (hatirin), near Bancal Barrio, Guagua, Pampanga Province, Luzon. The pond has been drained, and only a ditch has been left with water in it where the bañgos are crowded together and can be easily dipped up.

PLATE 10

FIG. 1. Fishponds and watchman's hut, at Samal, Bataan Province, Luzon.
2. A part of Doctor Valencia's fishponds, on Mactan Island, Cebu.
3. A part of Doctor Valencia's fishponds, on Mactan Island.

PLATE 11

FIG. 1. A poorly kept fishpond near Barotac Nuevo, the average type of pond seen in Iloilo Province, Panay.
2. A poor fishpond near Barotac Nuevo, Iloilo Province. A poorly kept nursery pond within a low dike and mangrove forest in the background.
3. Part of a good fishpond system near Dumangas, Iloilo Province, Panay. August 5, 1927.

PLATE 12

FIG. 1. A fishpond on the Polo plantation, Tanjay, Oriental Negros Province, Negros, with large dikes, and mangrove trees growing in the pond.
2. A fishpond of low salinity, less than 1 per cent, at Santo Rosario Barrio, Malolos, Pampanga Province, Luzon. Mudfish (dalag) can be found in this pond throughout the year. In the division on the right the water is almost entirely hidden by a dense growth of *Lemna*. The men are pulling up digman, aquatics of the genera *Ruppia* and *Najas*.
3. A fishpond of low salinity, never higher than 0.4 per cent, near Tinejero Barrio, Bacolor, Pampanga Province, Luzon. There is a patch of grass near the center of the pond and plenty of lumut, but this is not a first-class pond. The low salinity permits mudfish (dalag) to live in the pond throughout the year.

PLATE 13

FIG. 1. An abandoned fishpond near Hermosa Barrio, Orani, Bataan Province, Luzon.

FIG. 2. A small inclosure for catching bañgos that are ready for market. This pond has three sluice gates. Nipa palms show in the background. Malocan Barrio, Hagonoy, Bulacan Province, Luzon.

3. A small inclosure for catching bañgos that are ready for market. There are three sluice gates; the bamboo screen of the nearest gate is lifted. Carlos Palanca estate, near Hagonoy, Bulacan Province, Luzon.

PLATE 14

FIG. 1. A catching pond (kolonñgan) at Duniangas, Iloilo Province, Panay, having seven gates, five of which show in the picture.

2. A corral (baklad) for catching bañgos in Doctor Valencia's fishpond on Mactan Island. A barrier of boards ordinarily prevents fish from entering the corral.

3. The corral shown in fig. 2 with a part of the board barrier removed. The two men are catching bañgos with a net.

PLATE 15

FIG. 1. A bañgos pond at Batavia, Java.

2. Dike construction and main sluice gate, Batavia, Java.

3. Caretaker's house and bañgos ponds, Batavia, Java.

PLATE 16

FIG. 1. A fishpond being used for salt making. The pond is divided into small beds. A man is scraping up the salt. Dampalit Barrio, Malabon, Rizal Province, Luzon. May 12, 1927.

2. Salt-crystallizing pond and warehouse for salt at Malabon.

3. A man gathering salt into baskets. May 12, 1927.

TEXT FIGURES

FIG. 1. Plan and elevation of a fishpond sluice gate.

2. Plan of a bañgos nursery pond, at Dampalit Barrio, Malabon, Rizal Province, Luzon. This pond is used for salt making during the dry season. Below, a fish trap (galao).

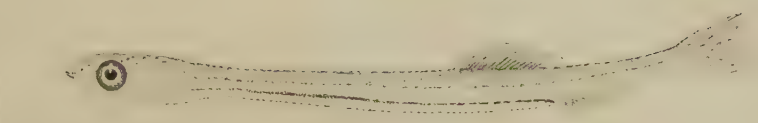
3. Plan of a part of a 20-hectare fishpond system with six 3-hectare catching ponds (kaloañgan). Paombong, Bulacan Province, Luzon.

4. Plan of a part of a 600-hectare fishpond system. The nursery will cost 4,000 pesos and will hold 1,500,000 bañgos fry (kawag-kawag). Ayala and Company, Macabebe, Pampanga Province, Luzon.

5. Plan of an 8-hectare fishpond system, showing the various parts.

6. Plan of a fishpond and small catching ponds used at Barotac Nuevo, Iloilo Province, Panay.

PLATE 1. BAÑGOS, OR MILKFISH, CHANOS CHANOS FORSKÅL.



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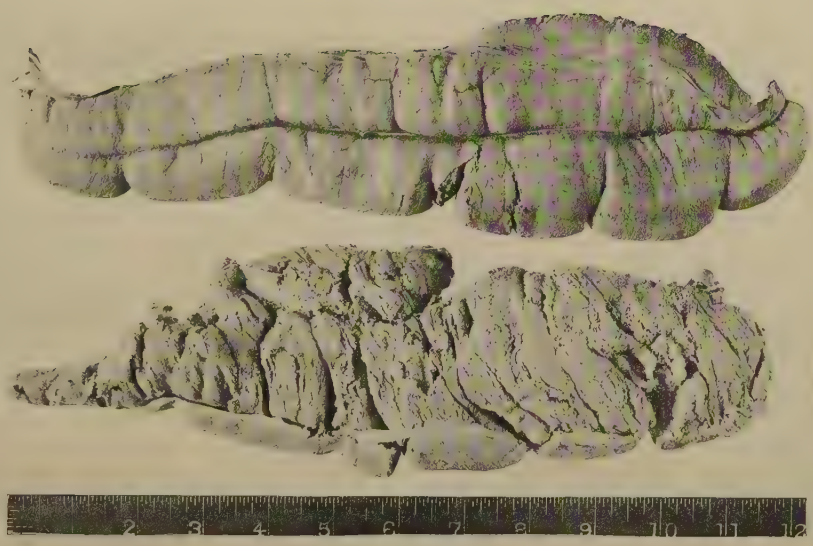

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PLATE 2.

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PLATE 3.

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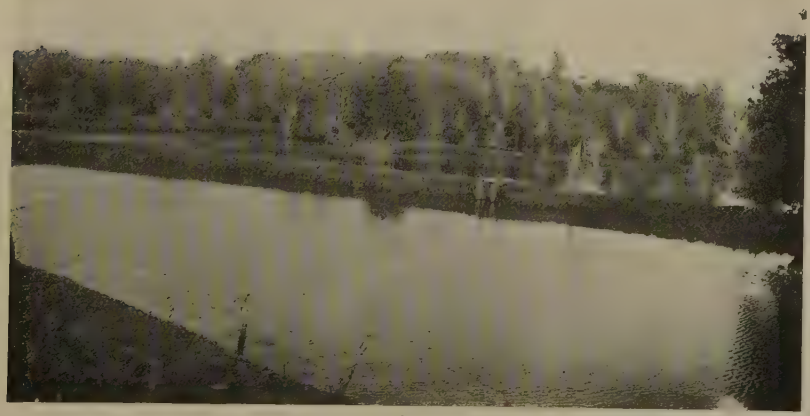

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PLATE 5.

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PLATE 8.

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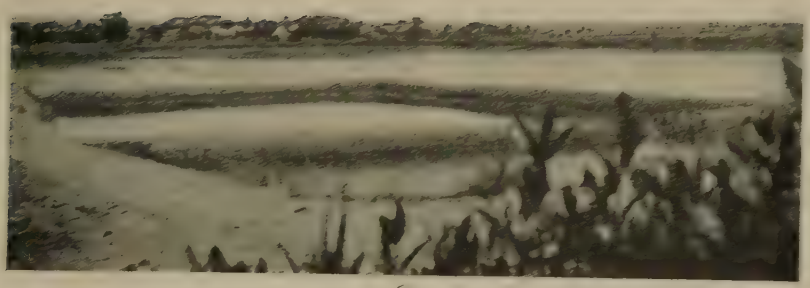

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PLATE 9.

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PLATE 10.

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PLATE 11.

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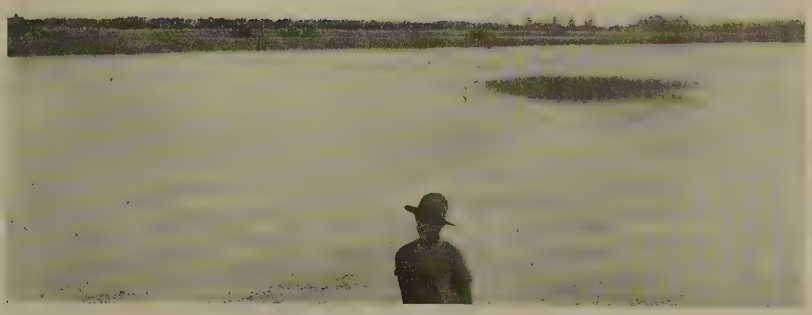

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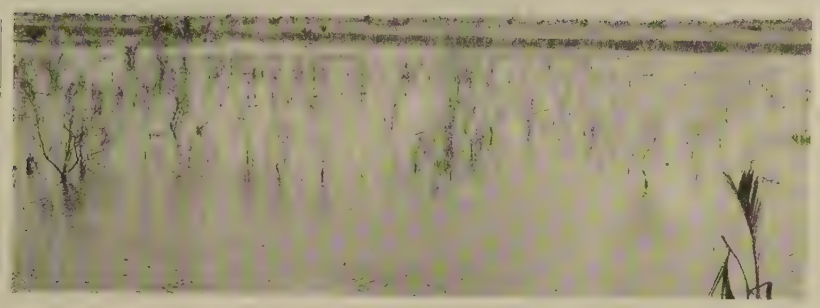
PLATE 12.



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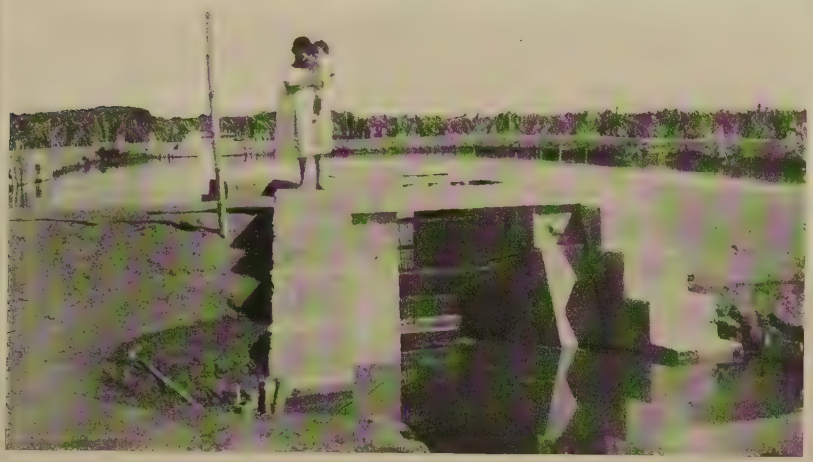

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PLATE 13.

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PLATE 14.

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PLATE 15.

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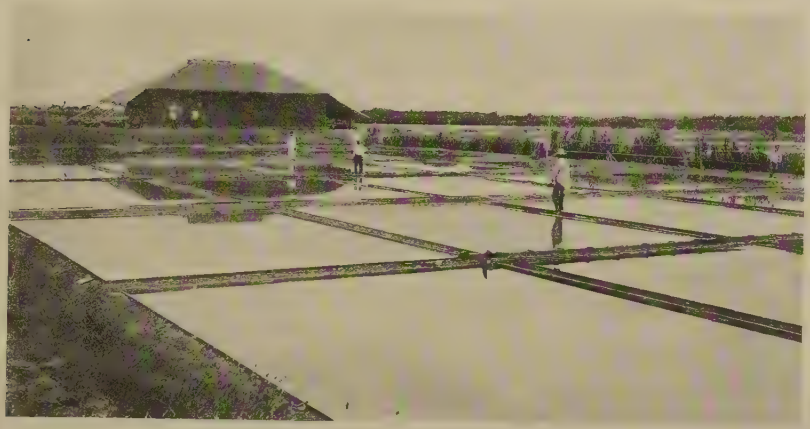

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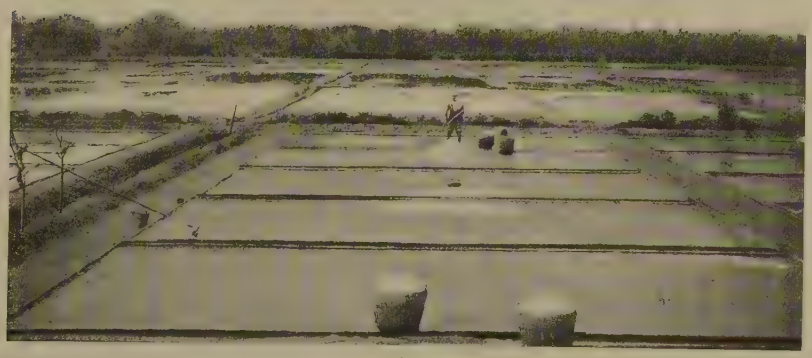

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[New names and new combinations are printed in **boldface.**]

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